MACHINERY.

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MAKING HEAVY STEEL FORGINGS.

NOTES UPON THE PLANT AND PRODUCT OF THE BETHLEHEM STEEL COMPANY.

The Bethlehem Steel Company, South Bethlehem, Pa., is known as one of the largest and most important steel plants in the world. We doubt, however, whether those who have not followed the course of events in the production of steel forgings during the past few years fully appreciate the unique and singularly distinctive part which this company have played in recent industrial progress.

In 1886 the Bethlehem Steel Company (then the Bethlehem Iron Co.) began negotiations with Sir Joseph Whitworth & Company, of England, and the Creusot Company, of France, for the establishment at South Bethlehem of a complete plant for making forgings for armor plates, guns and the necessary marine engine parts for the navy, with the result that eventually they had the most completely equipped plant for heavy forging in the world. The Whitworth Company controlled the famous "fluid compression" process for making steel for forgings, and the Creusot works at that time led in the production of solid steel armor plate, so that the introduction into this country of the methods of these two firms was an event of no small importance.

While these preparations were primarily for government orders, mainly for work upon war material, there has been a growing demand in commercial work for forgings to meet the specifications demanded by the government, and the changes that they have made possible in heavy machine construction is perhaps the most noteworthy sequence of the establishment of this plant.

Examples of this work are forgings made for the shafts of the American Line steamers St. Louis and St. Paul, 21 inches in diameter, and for the Long Island Sound steamers Pilgrim and Puritan; for the Ferris wheel shaft, which weighed 45 tons; for the field rings of the Niagara Falls generators (shown in Fig. 5); and latterly for the 4,000 horse-power engines for the Boston Elevated Railway (Fig 7), and the 8,000 horse-power units that are to be placed in the new power station of the elevated roads of New York.

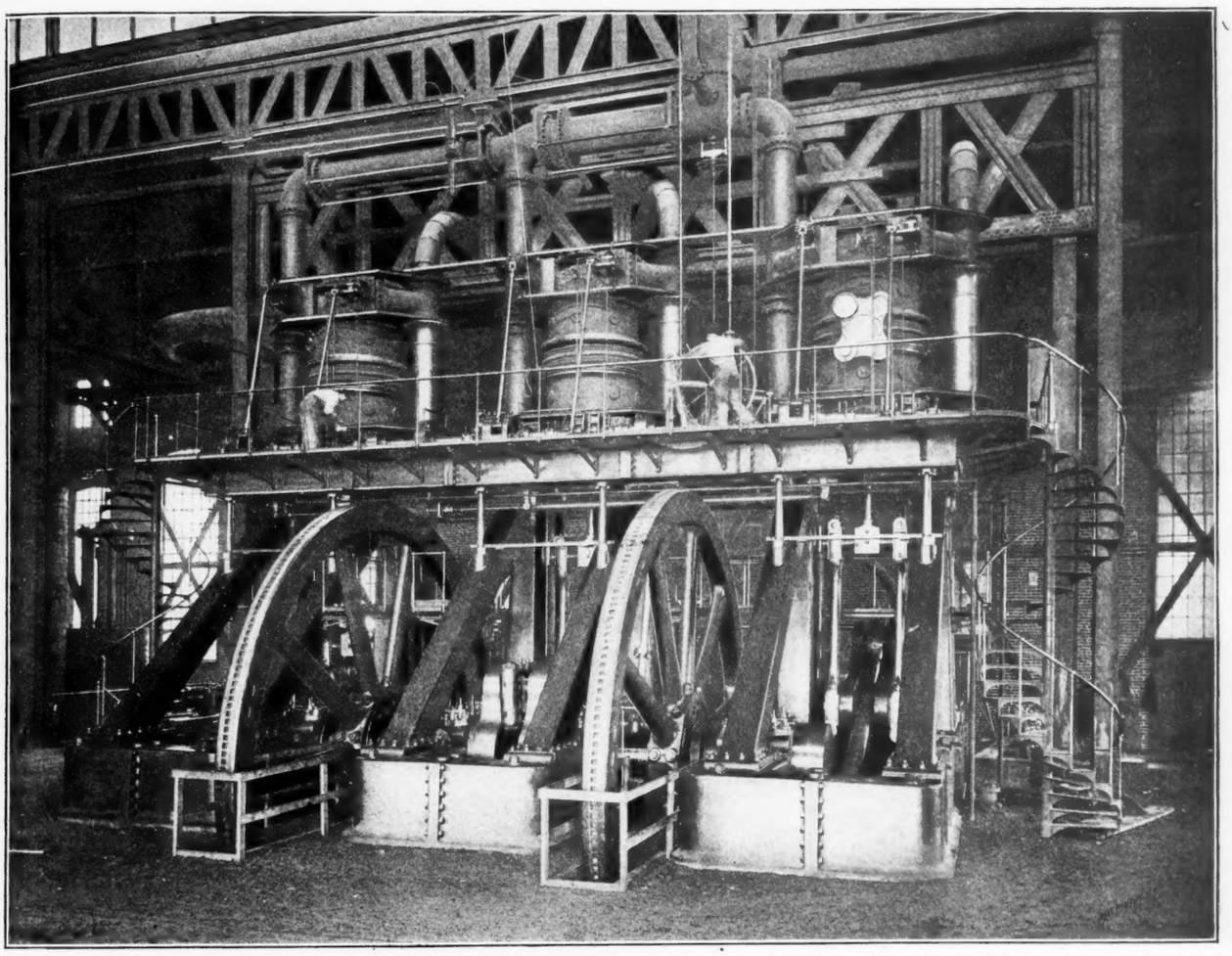

Fig. 1. Triple-cylinder, simple engine and pumps at the Bethlehem Works, serving the 14,000-ton forging press shown on the next page. Cylinders, 54 by 90 inches; steam pressure, 125 pounds; revolutions per minute, 60. The pumps are at the rear, have three 11-inch plungers and pump against a pressure of 7,000 pounds per square inch. This engine will develop 15,000 horse-power at about one-third cut-off and is said to be the most powerful land engine in the world. It was designed by E. D. Leavitt.

The installation of engines of the size of the last named is due directly to the fact that satisfactory forgings for their immense shafts can now be obtained, and when it is realized that these forgings have a tensile strength of 80,000 pounds, an elastic limit of 50,000 pounds, and an elongation under test of 25 per cent., they become of unusual interest to the engineer. We shall later try to show the full significance of these figures, but

will first recount briefly some of the salient features of the process of turning out these forgings as recently seen by the writer.

Steel Processes.

Steel is usually defined as a compound of pure iron and carbon, although there are always other elements present, certain of which, like phosphorus and sulphur, are detrimental, and others, like the nickel in the modern "nickel steel," are beneficial in their effects. The three principal processes for making steel are the Bessemer, the crucible and the open-hearth. Bessemer steel is made by forcing a powerful blast of air through molten pig-iron in a vessel called a converter. The effect of the blast is to burn out the impurities and decarbonize the iron, after which a sufficient quantity of pure cast iron, rich in carbon, is added, to give the steel the required percentage of carbon. This steel is the standard for rails, is used to a large extent for structural materials, and is entering the market for other purposes to an increasing degree.

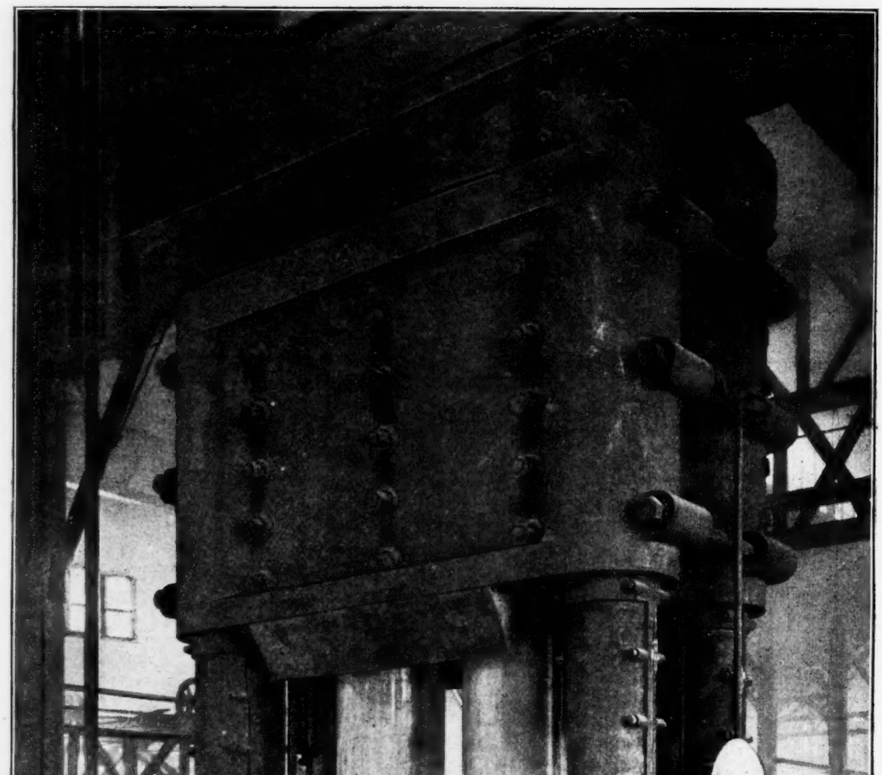

Fig. 2. 14,000-ton press for forging armor plate, large shafts, etc. Diameter plungers, 50 1-2 inches; stroke, 8 1-2 feet; capacity, 14 by 17 feet. On heavy work this press absorbs the full power of the 15,000 horse-power engine which serves it and at times almost stalls the engine. The engine pumps direct, no accumulator being used. Two-175 ton traveling cranes are provided for handling the forgings.

Crucible steel is the finest grade of cast steel, from which the best tool steels come. It is made by melting low carbon steels or bar iron in a crucible on contact with charcoal until they have absorbed the necessary amount of carbon.

Open-hearth steel is made by fusing together different ingredients, such as pig-iron and scrap steel of known qualities to give the composition wanted. The melting is done on an open hearth, enclosed only by the walls of the furnace, instead of in a crucible.

For forgings either the crucible or open-hearth steels are suitable. The crucible process is the older, and while it has been used successfully for casting large ingots, from which forgings were made, it is an expensive process and is not adapted to such work. The open-hearth process, on the other hand, enables large masses of metal to be fused without great difficulty, and is found to be well adapted for large ingots for forgings. It is even being used to a considerable extent for tool steels.

Open-hearth furnaces operate on the regenerative principle and temperatures of 3,000 to 4,000 degrees Fahr. are reached. The fuel is producer gas generated by burning coal in air-tight ovens with an insufficient supply of air fed in under pressure. The gas passes over the top of the hearth on which the melting is done, where it mingles with a separate supply of air and ignites. At each end of the furnace are fire brick passages, through one set of which the gas enters before ignition and through the other of which the products of combustion pass away. Every twenty minutes or thereabouts the direction of the current is reversed and the entering gas passes through the passages just heated by the intensely hot escaping gases, and passes out by the passage that has been cooled by the entering gas. This heating of the entering gas by the waste heat of the escaping gases is not only conducive to economy, but makes possible the extremely high temperatures produced in this form of furnace.

The Bethlehem Plant.

At the Bethlehem steel works there are four blast furnaces for making pig-iron, and in their rolling mill there are four Bessemer converters. Their open-hearth plant has eight open-hearth furnaces, four of which are 20 tons and four of 40 tons capacity, all on the regenerative principle. In Fig. 6 is a reproduction of a photograph taken during the casting of an ingot. On the platform at the rear are ranged the open-hearth furnaces from which the metal has been drawn into the ladles.

In Fig. 4 is a large ingot of special nickel steel for an armor plate. It is shown after it has been raised from the pit, and although this is not the largest ignot that has been cast here, its

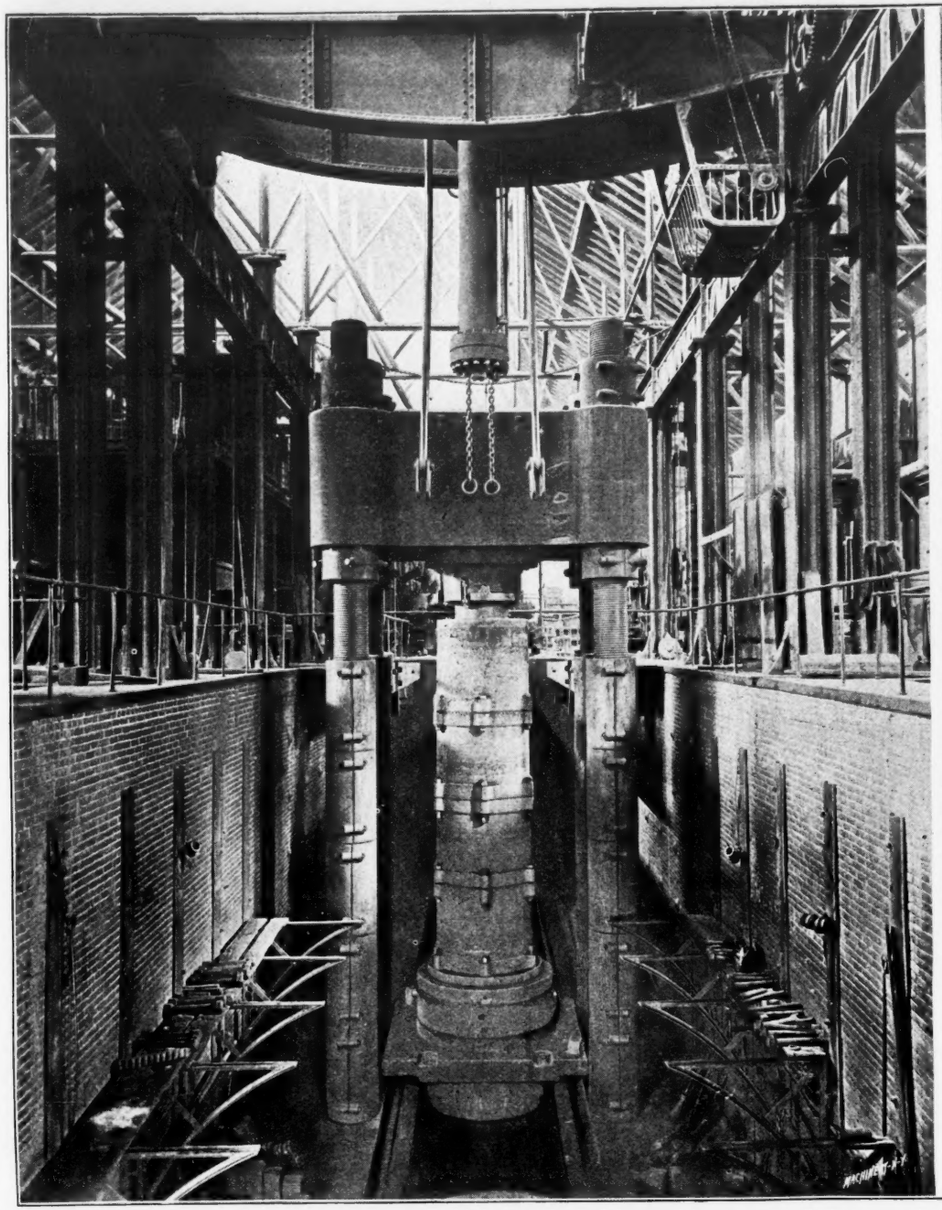

FIG. 3.

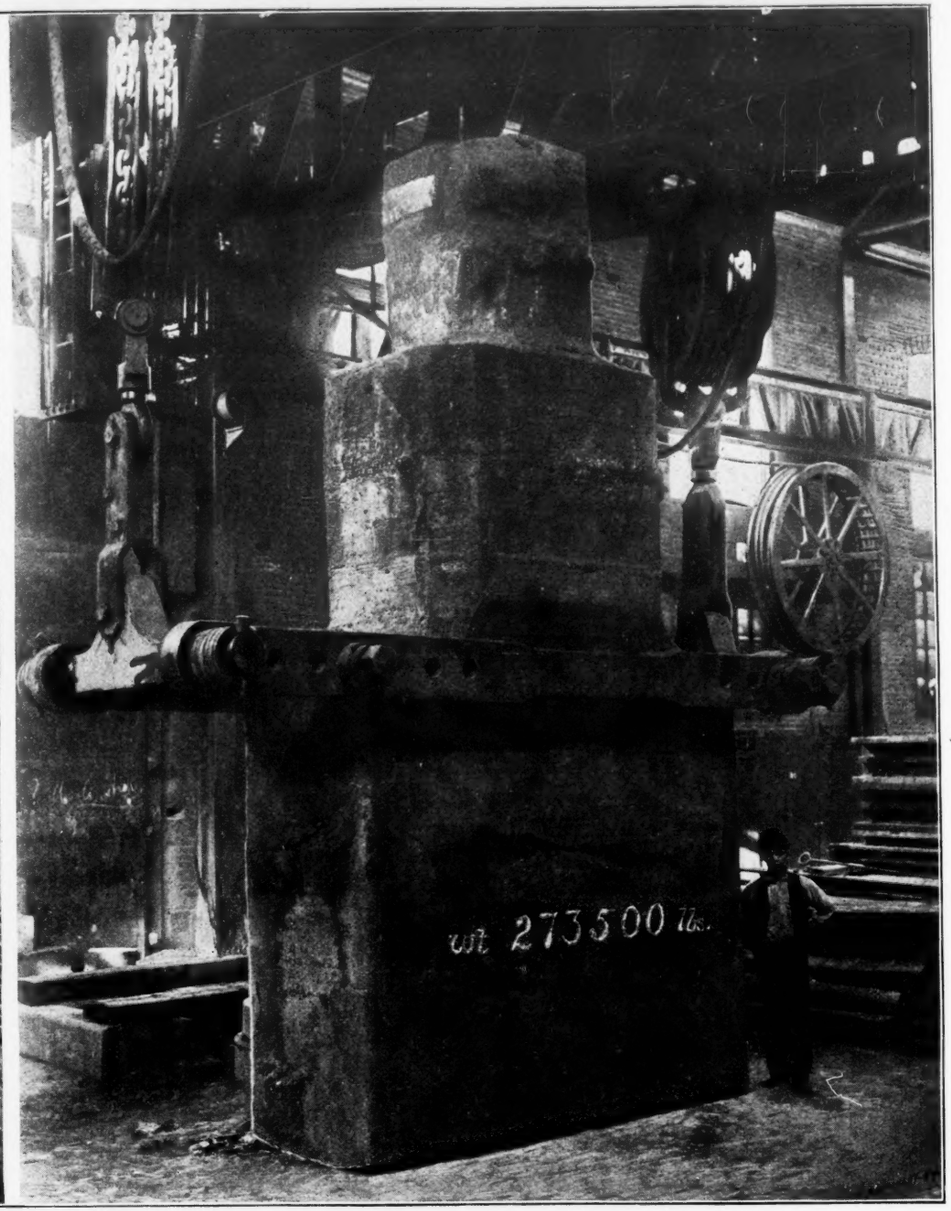

FIG. 4.

Fig. 3. Fluid compression plant. The molten steel is poured in steel molds and subjected to pressure under the press while it cools. The illustration shows a mold in position, while pressure is applied by the plunger at the base. The upper head of the press weighs 135 tons and the lower one, which is below ground, 120 tons. The four screws are about 15 inches diameter by 50 feet long. The press has a capacity of 7,000 tons and is served by a 125-ton hydraulic crane. Fig. 4. Nickel steel ingot weighing 273,500 pounds, or 122.1 gross tons. Cast for a 17-inch armor plate for a 12-inch gun turret.

weight of 122 tons and its size, compared with the man standing by its side, will give a forcible idea of the enormously heavy work that this plant is capable of casting and forging. The riser at the top of the ingot collects the impurities of the metal and also serves as a projection by which the piece can be handled in forging. This projection fits into a large sleeve or collar, cylindrical on the outside and with a square hole. The sleeve is held and rotated by the crane and the ingot is balanced by a long bar extending from the back end of the sleeve.

The Fluid Compression Process.

In casting ingots for guns, shafts and similar work, the Whitworth fluid compression process is employed, which gives the most perfect results of any known method.

Large wrought-iron forgings are made by welding together smaller pieces of iron, building up the completed forging piece by piece. Steel does not possess the property of welding to such a degree as wrought iron, and moreover, can be cast into any necessary shape. The proper way to forge steel, therefore, is to cast ingots considerably larger than the finished product is to be and draw it out under the hammer or forging press. For the

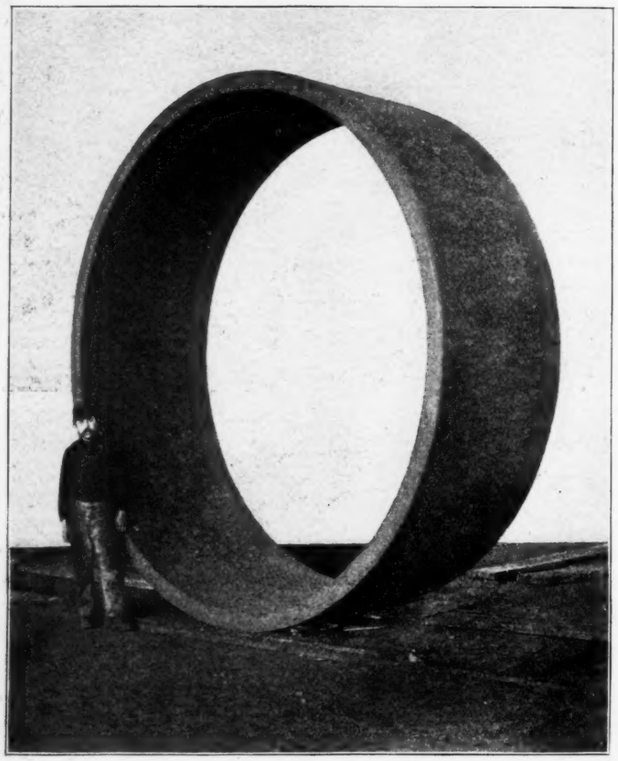

Fig. 5. Nickel steel field ring for a 5,000 horse-power generator at Niagara Falls. It was forged without a weld and weighed, after roughing out in the machine shop, 28,840 pounds. Outside diameter, 139 inches. When finished it was larger than the capacity of the furnace at that time, so that, if it had been imperfect, it would have been impossible to reheat it.

majority of work the most convenient ingot is in the shape of a cylinder, and in cooling, after it has been poured, it is found that certain defects creep in, which it is the object of the Whitworth process to eliminate.

The first part to cool, of course, is the outside, and as the metal gradually cools toward the center it shrinks away from it and causes "piping" or the formation of cracks. Blow holes occur, owing to the generation of gas and the air entrapped during the pouring, which tend to make the ingot unsound. It is desirable to have these defects remedied in the ingot because the steel will not weld, and any defect at the start will be carried through to the end. Still another difficulty is that of "segregation," or the separation during cooling of the particles of which the steel is composed, owing to the different specific heats of the different elements, and hence the different lengths of time required for them to cool. The segregation is mainly at the center and near the top of the ingot, so the ingot is cast somewhat longer than required for the forging, that the upper part may be cut off and remelted.

These cylindrical ingots are poured in steel molds which are lined with cast iron staves, grooved to allow the gases to escape at the ends. Inside of the staves is a lining of some refractory material. The molds rest on a car at the bottom of a long pit, which is deep enough to allow the top of the mold to reach to about the floor level. The molten steel is then poured from ladles like those in Fig. 6, which run on tracks on each side of the pit, and are thus carried directly over the molds.

After pouring, the mold containing the molten metal is moved by hydraulic pressure under the press shown in Fig. 3, which is the central and important feature of this department; not only as regards proportions, but in respect to its influence upon the product. The fluid steel is here subjected to a gradually increasing pressure during the cooling, causing the impurities and gases to segregate toward the center of the ingot. The outcome is an ingot of close and uniform texture that is solid throughout with the exception of the center, which is afterwards removed by boring. It takes eight or ten hours for an ingot to cool sufficiently to be removed, and during that time it is compressed about 10 per cent. in length. Ingots of this description have been cast 54 inches in diameter and about 16 feet long.

Forging Department.

Now we come to the forging plant. Most of our readers know that there is here located the 125-ton hammer, the largest in the world, a model of which was exhibited at the Columbian Exhibition at Chicago, but it will probably be a surprise to many to learn that this hammer stands idle, although ready for use if required. All forging, except on small pieces, is done by hydraulic presses. The largest steam hammer in actual use is a six-ton hammer in the blacksmith shop.

The object of forging by hydraulic pressure instead of by the impact of the hammer blow is to allow the metal time to flow while being operated upon. The action of a hammer, especially when too light for the work, is to pene the outside of the piece, leaving the inside practically as it was originally. This is seen in the appearance of the ends of heavy forgings, which have a concave appearance when forged under the hammer, showing that the outer metal has been worked the most, while a similar piece forged under pressure will actually appear convex at the ends.

The main outfit of the forging plant consists of the 14,000-ton press shown in Fig. 2, operated by the 15,000 horse-power engine shown in Fig. 1; two similar but smaller presses of 5,000 and 2,000 tons respectively, operated by engines of 3,500 horse-power, and a bending press having two 36-inch plungers and 4 feet 8 inches stroke. This latter press is served by two cranes of 65-tons capacity, will take work 8 by 12 feet, and operates under a pressure of 7,000 pounds per square inch. This department is also equipped with heating furnaces, which heat the ingots, preparatory to forging, to the mild temperature of 1,200 or 1,500 degrees. That this is mild in comparison with the open-hearth furnaces is painfully evident to one who attempts to look into both of them, as did the writer.

The two smaller presses were obtained from the Whitworth works at about the same time that the compression plant was installed, and their satisfactory working led to the construction of the 14,000-ton press at the Bethlehem works. The fact that the company should construct so massive and expensive a group of machinery as this press with its crane, hydraulic apparatus and engines, shortly after building the giant 125-ton hammer, simply because it would do the work better than the hammer could do it, speaks volumes for the enterprise of the Bethlehem Steel Company and their determination to produce only the best products that can be made.

To the uninitiated it seems incredible that the full power of a 15,000 horse-power engine should be required to operate this one press, as stated under Fig. 2, but the writer was assured that such was the case, and a few figures show that it is not at all improbable. The hydraulic pressure at the pumps is 7,000 pounds per square inch, and the combined area of the two 50½-inch plungers of the press is 4,000 square inches. This times 7,000 pounds gives 28,000,000 pounds, or 14,000 tons, which is the rated capacity of the press. Fifteen thousand horse-power is equivalent to 45,000,000 foot-pounds per minute, and this quan-

tity divided by 28,000,000, the pressure exerted, gives 17.6 as the number of feet per minute that must be traveled by the head to utilize 15,000 horse-power, supposing there to be no loss and that no power is required to raise the head after each stroke. Probably these two items would take at least one-third of this power, making the actual number of working feet required about 10 or 12, which is quite reasonable. The engine itself is a handsome machine designed by E. D. Leavitt. The pumps are ranged horizontally at the back of the engine and receive their motion from the steam cylinders through bell cranks, no power being transmitted through the shaft except to and from the fly-wheels.

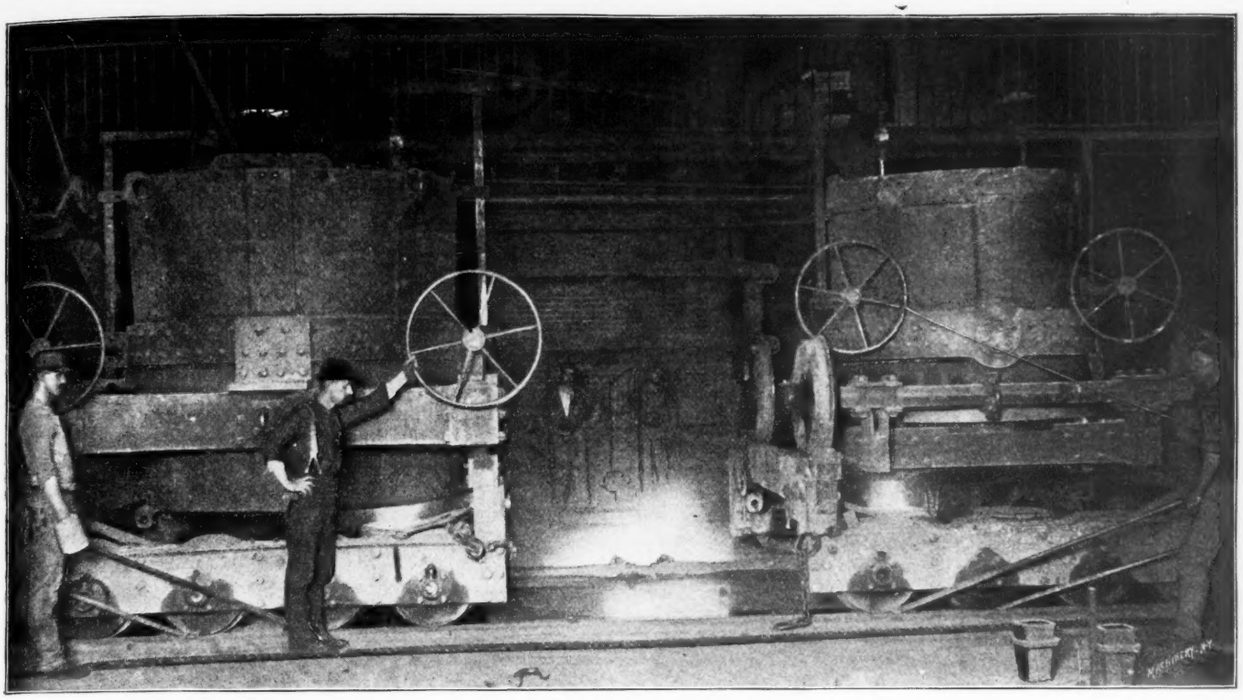

Fig. 6. Pouring an armor-plate ingot. Open-hearth furnaces on the platform at the rear.

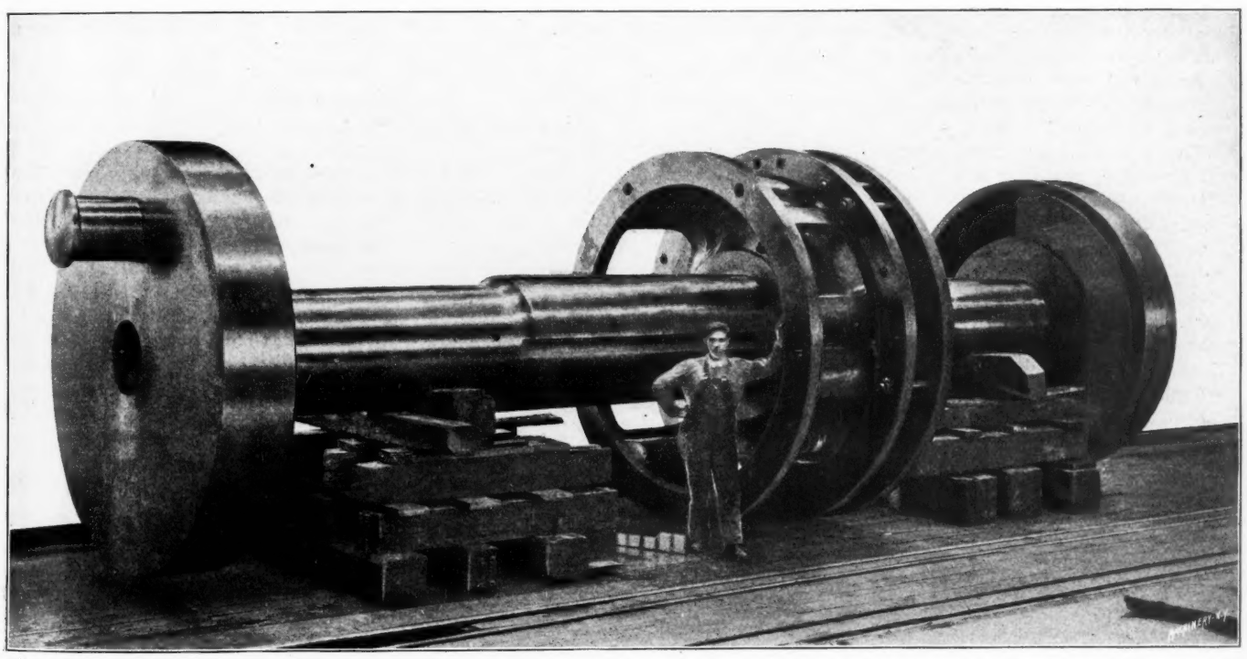

Fig. 7. Shaft of fluid-compressed, nickel steel, hydraulically forged on a mandrel, oil tempered and annealed, for Boston Elevated Railroad engine. Diameter in center, 37 inches; diameter of journals, 34 inches; diameter of axial hole, 17 1-2 inches; weight of shaft, exclusive of crank disks and hub, 65,400 pounds. The properties of the steel of the shaft are, elastic limit, 50,000 pounds per square inch and elongation 18 per cent. in test pieces 1 inch in diameter and 10 inches long.

Hollow Shafts.

As intimated at the beginning of these notes, while the equipment of the Bethlehem Steel Company was designed primarily for producing armor plate, gun forgings and other government work, engineers engaged in lines of industrial work are taking advantage of its facilities and a large number of the forgings turned out are to supply this demand. Quite as important and as typical work as any is the making of large hollow shafts for steam engines, and a brief explanation of why these shafts are made hollow and of what results are obtained with them will probably be more instructive to the average reader than more detailed descriptions of other parts of the work and equipment.

It has already been stated that by the fluid compression process ingots are produced that are practically free from the defects of piping, blow holes and segregation; and that if there are any impurities they will occur at the center, which is bored out, leaving a perfectly sound cylindrical ring.

It might be supposed that the best way to make a hollow ingot would be to cast it hollow; but if this were done there would be two cooling surfaces while the ingot was solidifying, the interior and the exterior, and the metal half way between these, or at the central portion of the metallic ring, would be the last to cool and would contain the defects, which could not be eradicated. The casting would thus be far inferior to a solid casting bored out after cooling.

Another advantage of the hollow ingot over the solid one is that there is less danger in heating it to the temperature required for forging. The unequal strains incident to heating a large body of metal are likely to start a fracture which cannot be remedied in the forging. When a solid piece is treated the outside expands and tends to pull away from the interior. With the hollow ingot the heating takes place from both the interior and exterior sections and is more uniform.

When it comes to the forging, a steel mandrel of the size of the core that was bored out is inserted in the center, which amounts practically to reducing the thickness of the metal to be operated upon to less than one-half of what it would be if the ingot were solid. The mandrel acts virtually like an anvil at the center of the ingot and the annular ring of metal can be worked thoroughly, through and through, by the forging press, making it of superior texture. The importance of such working is shown by tests upon the first shaft of the U. S. dispatch boat Dolphin, which broke after a short service. The shaft was solid, 16 inches in diameter, and was forged from a large steel ingot under a 10-ton hammer. A test-piece from the outside, which had been worked, elongated 21 per cent. before breaking, while one from near the center, which had been scarcely affected by the hammer, elongated only 2 per cent., or practically was not ductile at all.

After a forging is completed, up to this point, it is then annealed to relieve the unequal strains that have been set up by the heating and forging. To use technical language, the shaft is heated to above the recalescent temperature and then allowed to cool slowly. This temperature lies between 1,200 to 1,300 degrees, Fahr., and is the point at which, if a piece of red-hot steel be allowed to cool, its temperature will cease to fall for a short time, or even may rise again, and then the same rate of cooling will continue as before this point was reached.

At the recalescent point the structure of steel seems to change; the old crystals rearrange themselves into new forms and internal strains are relieved.

The highest grades of shafting are oil-tempered by cooling in oil after they have been heated for annealing. The process of annealing reduces the elastic limit to below half the tensile strength, and oil tempering restores this property of the metal.

In Fig. 7 is an excellent illustration of the work done in the line of hollow shafts. Complete data are given under the illustration and it is only necessary to refer to these to convince one of the superior quality of the product. The fact that mild steel, which was formerly used when steel forgings began to be introduced, had an elastic limit of only 30,000 pounds, and that wrought-iron has but two-thirds of this, shows what can be gained in lightness and strength with the perfected material. Nickel steel may be stated roughly to contain 3¼ per cent. of nickel and from .30 to .40 per cent. carbon, the effect of the nickel being to raise the elastic limit without destroying the ductility. The high elastic limit of this steel combined with its ductility, makes it well adapted to withstand the alternating stresses that are imposed upon it. For as long as these stresses do not exceed the elastic limit and the shaft is a perfect forging, as a hollow shaft made by this method is quite sure to be, it should be absolutely safe.

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As a preparation for his future work a young engineer cannot do better than to become a close reader of the current periodicals which have for their field his chosen profession. Let him follow the discussions and if possible take part in them; in order to do this with credit to himself, he must become familiar with the subject, and having once mastered it will easily recognize it when after a period of eight or ten years that same subject appears again thinly disguised and heralded as something that is really new. Many questions have a way of reappearing at more or less regular intervals, so that the elders of the profession have met most of them more than once."—Daniel Royse, in "Purdue Exponent."

THE OCEANIC

FEATURES OF INTEREST ABOUT THE LARGEST AND NEWEST OCEAN LINER.

The new White Star liner, the Oceanic, made her first trip across the Atlantic and arrived at New York harbor September 13th, after an uneventful voyage requiring a few hours over six days.

This huge vessel, the largest ever constructed, has occasioned considerable interest not only on account of her mammoth proportions, but because her building marks the great advance that has been made in maritime engineering since the days of that monumental failure, the Great Eastern. The dismal failure of this vessel had apparently set a limit to which no vessel could approach with any assurance of success, but the Oceanic exceeds the former vessel in dimensions, tonnage and power, although her engines consume only a fraction of the vast quantity of coal necessary for the propulsion of the great side-wheeler. The fuel consumption is an important factor in the status of an ocean vessel as a paying investment, and was one which caused the Great Eastern to prove a non-paying investment, as she required 12,000 tons for a round trip to the Orient, while the Oceanic, thanks to the greater efficiency of modern engines and boilers, has a steaming radius of nearly the same distance, or 24,000 miles, with a consumption of less than 4,000 tons.

The new steamer is 704 feet long, 68 feet wide, has a molded depth of 49½ feet, and total depth of 68 feet. Her draught when fully laden is 35 feet, but as the depth of the Sandy Hook channel is only 30 feet at high tide, it is evident that she cannot enter New York Harbor with a maximum lading until a deeper channel is provided. Her displacement is given as 28,000 tons, which, however, is increased to over 30,000 with the maximum draught. The engine power is rated at 28,000 H.P. with a steam pressure of 190 pounds per square inch, which is a striking contrast to that carried by the Great Eastern's boilers. The latter were intended for a pressure of only 20 pounds per square inch, and with the enormous consumption of coal were enabled to develop at the best, only about 8,000 H.P., which was divided between the side wheel and a supplementary screw. The latter's engines being of 4,500 H.P. and those for the side-wheels being 3,500 H.P.

The Oceanic, being a twin-screw ship, has two independent engines which are of the triple expansion four-crank type. the cranks being set so that practically equal turning moment is obtained at all points of rotation. The diameters of the steam cylinders are 47½ inches for the high-pressure, 79 inches for the intermediate, and 93 inches for the two low-pressure cylinders. The screws are so very close together as to necessitate an opening through the stern between them. The rudder is of extremely heavy construction and is of course provided with steam steering gear and also a hand gear to be used in an emergency. The steering gear is of very massive build and is provided with independent engines, so that in case one is disabled the other engine can be quickly brought into gear.

SOME OF THE DIMENSIONS OF THE LARGEST OCEAN VESSELS.

Name.	Length, feet.	Beam, feet.	Depth, feet.	Draught feet.	Displacement, tons.	I. H. P.	Speed, knots.
Oceanic.....	704	68	49½	32½	28,000	28,000	21
Great Eastern...	692	83	57½	25½	27,000	8,000	14½
Deutschland.....	662	67½	44	..	23,000	35,000	23
Kaiser Wilhelm Der Grosse....	649	66	43	29	20,000	27,000	22½
Campania.....	625	65	41½	28	19,000	. ....	22
Lucania.....	600	65	41½	..	19,000	30,000	22
Teutonic..... ..	585	57½	42	27	15,000	.....	20
Paris.....	560	63	42	26½	13,800	.....	20
City of Rome....	560	52	34½	..	12,000	11,000	17
St. Paul.....	554	63	42	27	16,000	.....	21
La Touraine.....	520	68	34½	..	12,000	12,000	19
Statendam.....	525	60	43½	..	17,000	6,200	15

There are fifteen boilers, twelve of which are double-ended and the other three single-ended. It is said that the weight of the entire battery is nearly 1,100 tons. It by no means follows, however, that all these boilers are required for the main engines, as there are between seventy and eighty auxillary engines for operating the hoists, electric lighting apparatus, pumps, fans, etc. As these engines are distributed throughout the ship wherever needed, and as they require steam pipes from the boilers and exhaust pipes to the condensers, it follows that there is a very complicated mass of piping required in the aggregate. Twenty

engineers are required to look after the various units throughout the vessel, including the electrical and refrigerating engineers with their assistants. One of the impressive features of the Oceanic are the two towering funnels which reach 140 feet above the keel. Their shape is elliptical in sections, the two diameters being 15 and 19 feet, which, however, is less than the diameters of the stacks for some of the Cunard ships.

While the dimensions of the Oceanic are enormous, her lines are so trim and well proportioned that the impression of size is not realized until she is compared with the pier shed or to one of the saucy little tugs that bustle so busily about New York Bay and the Hudson River. An interesting sight is that presented when such a vessel as the one under consideration is being docked and seven or eight tugs are all working with their noses against the side of the vessel to counteract the effect of the tide so that no damage shall be done to the piers while the ship slowly moves up to her position.

A peculiar feature of the construction is the use of huge round head rivets in the upper rows of plates, while those below are of course countersunk so that a smooth surface is obtained. The plates are of extraordinary thickness, and it is said that the rivets used are of a larger diameter than have ever been used throughout the construction of a similar vessel. The use of such large rivets was possible by the use of huge hydraulic riveting machines on all parts of the ship, practically no hand riveting being done on her plates or frame work.

The vessel has seven decks exclusive of that on which the officers' quarters are placed, and which is also used for the storage of the life boats. The accommodations for the passengers are very complete, especially those for the first and second cabins, and even the steerage is said to be superior in the general conveniences and comfort to the second cabin arrangements of only a few years ago. All details are carried out with extreme nicety, and the finish of all the parts of this immense structure is one of the things that most impress a person who understands the vast amount of labor required to secure such results. The total cost of the Oceanic, which was built at Belfast, Ireland, by Harland & Wolff, is said to be nearly $5,000,000.

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STANDARD KEYS.

PROPORTIONS FOR STRAIGHT AND TAPER KEYS, WITH DERIVATION OF THE FORMULAS.

HENRY HESS.

In determining a standard it is proper to consider just what offices the thing to be standardized is to perform, and the conditions of its use.

All keys to be discussed are intended to transmit motion from a shaft to a surrounding hub, or vice versa, in doing which the force acting on the key tends to produce, first, tilting of the key in its seat, and, second, a shearing of the key along the joint of hub and shaft. The first of these tendencies is restrained by the depth of the key; the greater this is the less tendency to rock; but letting the key in deeply tends to weaken both hub and shaft, and it therefore becomes necessary to compromise. A very good proportion for depth and one already largely adopted is to make

$K = \frac{3}{16} d + \frac{1}{16}$, where K is key depth and d is shaft diameter. For most cases a key of square cross section is preferable, so that $w = K = \frac{3}{16} + \frac{1}{16}$, where w is key width.

Such a width and depth will weaken a shaft against tension by only about 7 per cent., one half of the key being let into the shaft.

The second of the destroying tendencies, the shearing of the key, is resisted by giving the key a proper area of shearing section; this area = l w, where l is length of key and w is width of key as before.

As w is already empirically determined, only l remains to be found. If the shearing area is made such as to have a resistance to shear equal to that of the shaft against tension it will be ample. Such area will be secured if $l = 1.65d - 0.35$, or for diameters up to 6 inches a simple formula, giving somewhat greater strength, is $l = 1.6d$.

This, of course, means not that l must always be made to conform to the value given by the formula, but that it should never be less.

Proofs of these Formulas.

For those interested, the proofs are as follows:

KEY LENGTH.

$L = l\,w\,f$ ..... I.

Where L is load acting at shaft radius,
w is width of key,
f is shearing stress,
l is length of key.

The formula for shaft under torsion is

$L = \frac{\pi}{16} f_1 \frac{d^3}{r}$ where ..... II.

v is shaft radius,
d is shaft diameter,
f_1 is torsional stress,

but as resistance to torsion of any given material is 4-5 of that to shear, f_1 of equation II equals 4-5 f, and as $r = \frac{d}{2}$ equation II may be written.

$L = \frac{\pi}{16} \frac{4}{5} f \frac{d^3}{\frac{d}{2}} = \frac{\pi}{16} \frac{8}{5} f\,d^2$ ..... III.

From I. and III. it follows that

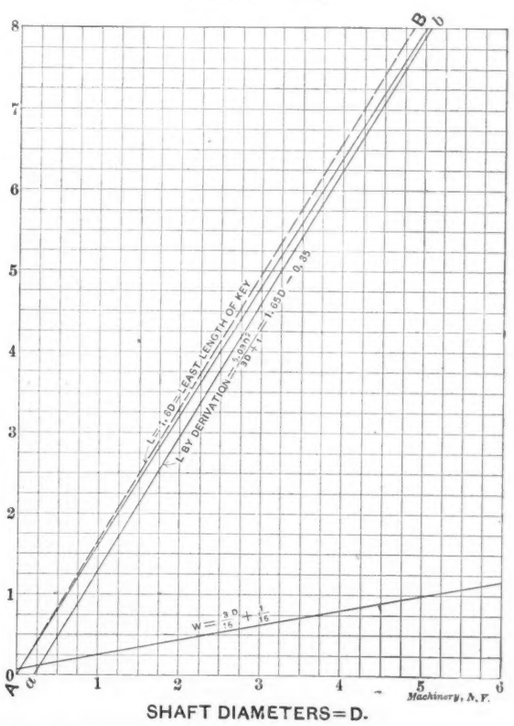
$l\,w\,f = \frac{\pi}{16} \frac{8}{5} f\,d^2$, and cancelling f gives

$l\,w = \frac{8}{16} \frac{\pi}{5} d^2$; but as $w = \frac{3}{16} d + \frac{1}{16}$

$l \left(\frac{3}{16} d + \frac{1}{16} \right) = \frac{\pi}{16} \frac{8}{5} d^2$, which transposed and reduced gives

$$l = \frac{\pi}{16} \frac{8}{5} \frac{d^2}{\frac{3}{16} d + \frac{1}{16}} = \frac{\pi}{16} \frac{8}{5} \frac{d^2}{\frac{1}{16}(3d + 1)} = \frac{5.03\,d^2}{3d + 1}$$

DIMENSION CHART.



SHAFT DIAMETERS = D.

This formula may be simplified by graphic method, as follows: First calculating a number of values of l gives

l	d
1	1.26
3	4.53
4.5	7.44

Plotting these values of l as ordinates to the values of d as abcissae on a piece of cross section paper gives a line a b that intersects the base between o and 1. Draw a line A B from o parallel to a b; at any value of d measure the ordinate to A B and divide the value thus found by d. At d = 4.5 the ordinate measures 7.44 and $\frac{7.44}{4.5} = 1.65$. Next

measure vertically from a to B, which is found to equal 0.35. Therefore

$l = 1.65\ d - 0.35$.

Drawing a line from o to point d = 5 on line 8 of the diagram gives a formula for l having only a constant multip ier and dropping the second term, or $l = \frac{8}{5} = 1.6\ d$.

It will be noticed that this formula gives values slightly large for all values of d below 6".

This graphic method for simplifying formulae may very often be put to good use, whenever the line representing the plotted values is a straight one.

Weakening Due to Keyway.

The statement made in the beginning that a width $w = \frac{3}{16}\ d + \frac{1}{16}$ and depth $\frac{w}{2}$ of the keyway weakens the shaft by only 7 per cent. is proven as follows:

The polar moment of J of a shaft of circular crosssection is $J = \frac{\pi}{32} d^4$.

The polar moment J, of a shaft having a keyway cut out is J minus the polar moment of the section cut out referred to the shaft center; this latter moment is the sum of two equatorial moments around axes at right angles to one another and passing through the shaft center; these equatorial moments are:

J_2 around a a, and J_3 around b b. See diagram.

$$J_2 = \frac{w}{2}\frac{w^3}{12} = \frac{w^4}{24}$$

$$J_3 = \frac{w}{12}\left(\frac{w}{2}\right)^2 + A^2\left(w\frac{w}{2}\right) = \frac{w^3}{48} + \frac{(A\ w)^2}{2}$$

$$J_1 = J - (J_2 + J_3)$$

Let d = 1, then

$$w = \frac{3}{16}d + \frac{1}{16} = .25$$

$$A = \frac{d}{2} - \frac{w}{4} = \frac{1}{2} - \frac{.25}{4} = .4375$$

$$J_2 = \frac{w^4}{24} = \frac{.25^4}{24} = .00016$$

$$J_3 = \frac{w^3}{48} + \frac{(A\ w)^2}{2} = \frac{.25^3}{48} + \frac{(.4375 \times .25)^2}{2} = .00631$$

$$J = \frac{\pi}{32} d^4 = \frac{\pi}{32} 1^4 = .09817$$

$$J_1 = J - (J_2 - J_3)\ .09817 - .00016 + .00631 = .0917$$

$$\frac{J}{J_1} = \frac{.09817}{.0917} = 1.07, \text{ that is}$$

the shaft without keyway is 1.07 times or 7 per cent. stronger than with keyway.

Strictly this analysis is not quite correct. If a shaft be conceived as being pierced with a very narrow sawslit in the direction of its length, so narrow that the amount of material removed is practically nil, it is very clear that it will not be as strong to resist tension as it was before cutting. This is, however, an extreme case, and though the amount of weakening as above is understated it is for the depth of keyway given not seriously so.

The table gives the dimensions of straight and taper keys, and may prove a useful addition to other data published by MACHINERY.

Standard Taper Keys.

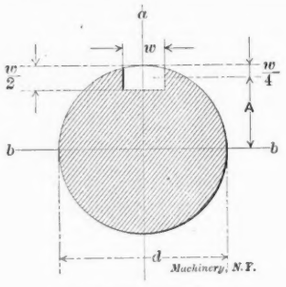
Taper keys are called on theoretically to act only by frictionally binding together shaft and hub, all driving to be due to this frictional hold only. As a matter of fact, taper keys are more or less liable to be jarred loose, and can therefore not be relied on to secure a driving by friction only, so that, as in the case of ordinary keys, their area of cross-section at the junction of hub and shaft should be relied on to be on the safe side, thus narrowing the junction of the taper down to a more or less efficient means of keeping the key in place. General practice seems to argue that a taper of one in sixty-four is a fair value and gives dimensions that work in well with the usual subdivisions of the inch. In Europe a taper of one per hundred is generally employed, agreeing better with the decimal system in use there.

As the key has finally to act in a manner similar to the ordinary flat key, its dimensions will be governed by similar considerations, so that the width and average depth are as before

$$w\ \tfrac{3}{16}\ d + \tfrac{1}{16}$$

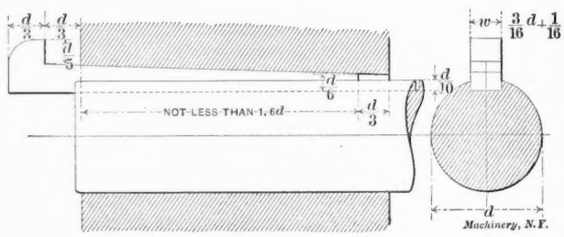
Keys proportioned as that shown will be found to give a fair shoulder both at the head and point to drive against in backing out, with sufficient clearance for occasional tightening, and a symmetrical head. All proportions are based as simply as pos-

KEY DIMENSIONS.



STRAIGHT KEY.

In the taper key the least length l is that at which the key in shear and the shaft in torsion have equal strength for the same material.



TAPER KEY.

TABLE.

d	Straight and Taper Keys. w	Straight and Taper Keys. w/z	Straight and Taper Keys. l	Taper Keys Only. d/3	Taper Keys Only. d/5	Taper Keys Only. d/6
1	5/32	5/64	3/4	5/32	3/32	3/32
1 1/16	3/16	3/32	1	3/32	1/16	1/32
1 1/8	3/16	3/32	1 1/4	1/16	1/32	1/32
1 3/16	1/4	1/16	1 1/2	1/32		
1 1/4						
1	1/4	1/16	1 1/2	11/32	3/16	3/32
1 1/16	1/4	1/16	2	11/32	1/16	1/16
1 1/8	1/4	1/32	2 1/2	1/16	1/32	1/32
1 3/16	1/4	1/32	2 3/4	1/16	1/32	1/32
1 1/4						
2	7/16	7/32	3 1/4	11/32	1/8	1/16
2 1/16	1/4	1/32	3 1/2	3/32	1/16	1/32
2 1/8	1/4	1/32	4	1/16	1/32	1/32
2 3/16	1/4	1/32	4 1/4	1/16	1/32	1/32
2 1/4						
3	5/16	5/32	4 3/4	1/8	1/16	1/32
3 1/16	5/16	5/32	5 1/4	1/8	1/16	1/32
3 1/8	1/16	1/32	5 1/2	1/16	1/32	1/32
3 3/16	3/8	3/16	6	1/16	1/32	1/32
3 1/4						
4	13/32	13/64	6 3/4	1/8	1/16	1/32
4 1/16	3/8	3/16	6 3/4	1/8	1/16	1/32
4 1/8	3/8	3/16	7 1/4	1/16	1/32	1/32
4 3/16	3/8	3/16	7 1/2	1/16	1/32	1/32
4 1/4						
5	1	1/2	8	1 1/16	1/4	1/8
5 1/16	1	1/2	8 1/4	1/4	1/8	1/16
5 1/8	1 1/16	1/16	8 3/4	1/16	1/16	1/32
5 3/16	1 1/16	1/16	9 1/8	1/16	1/16	1/32
5 1/4						
6	1 1/4	5/8	9 1/2	2	1 1/4	1

sible on the diameter. For very long keys of 5 dias or more a taper of one in sixty-four gives rather too great a depth under the head, and it is advisable to reduce this to one in a hundred; there is, however, very rarely any need of such keys, as a length of 1.6 dias is all that is required to secure strength fully equal to that of the draft.

The dotted lines of the dimension chart give the actual dimensions called for by the proportions given at the key, while the full lines give the absolute dimensions to be used.

* * *

To one with aesthetic tastes in machine design the English locomotive easily ranks ahead of the American. Its graceful and smooth contour is not marred by the numerous projections and irregularities found on our machines. But when it comes to repairs and the care of the machine—that is another thing.

MACHINE TOOLS, THEIR CONSTRUCTION AND MANIPULATION.—3.

TESTING AND ADJUSTING ENGINE LATHES.

W. H. VAN DERVOORT.

The size of a lathe is commonly determined by its swing and the length of the bed, the swing referring to the greatest diameter of work, when held on the face plate or in a chuck, that the lathe will turn over the shears. Thus, an 18-inch by 10 foot lathe means one that has a bed 10 feet long and will swing work 18" in diameter. The builder usually allows from ⅛ to ½ inch over the rated swing, thus making it possible to actually finish a piece of work of the same diameter as the normal swing of the lathe. The swing over the carriage and greatest distance between centres are also important dimensions. The former is usually from one-half to two-thirds the normal swing of the lathe.

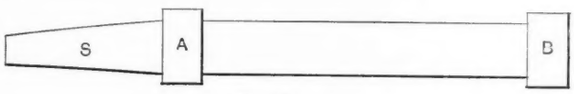


Fig.19

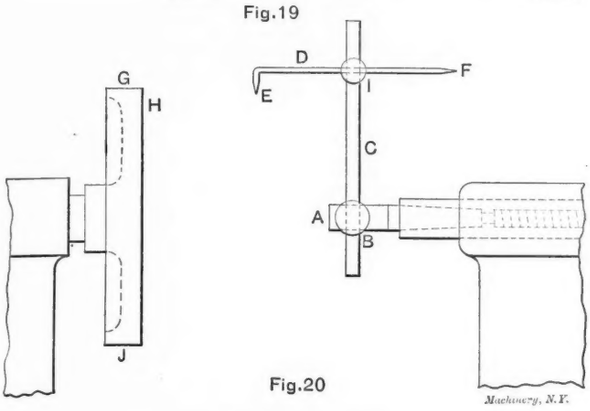


Fig.20

Machinery, N.Y.

The lathe should be well and accurately built, of ample weight, with operating parts conveniently arranged. Weight is desirable and usually indicates a first-class tool. This is not necessarily true, however, as frequently a badly designed machine will have certain parts excessively heavy with other parts correspondingly light, the whole often making an unusually heavy machine,—not so good as the lighter machine in which good judgment on the part of the designer has led to proper proportions for all the parts.

Lathe builders carefully test the accuracy of their lathes before sending them out. As it is frequently desirable for the mechanic to test his lathe as to accuracy of alignment, or in making repairs on lathes that have become inaccurate through wear, the following methods, commonly employed for this purpose, may be of value.

To determine if the centre bearing in the live spindle is axially true with its spindle: Turn up, on accurately ground centres, the test bar shown in Fig. 19. The shank S should fit the centre bearing nicely and the collars A and B should be exactly of the same diameter. Place the test bar in the live centre bearing, leaving it unsupported at the outer end, and cause the spindle to rotate. If the outer end of the bar runs perfectly true, then the bearing must be concentric with the spindle.

To test the parallelism of the live spindle and the shears: If the centre bearing has been found exactly concentric, place the test bar in the bearing as before. Put a fine pointed tool or scriber in the tool post and so adjust that it will just touch the top of the collar A. Now move the carriage until the pointer is over the collar B. If it touches it with the same degree of contact as on A, the spindle must be horizontally parallel with the shears and line of motion of the carriage. In like manner test the front side of the collars A and B with the scriber, and if as before the degree of contact is the same on both, the spindle must be vertically parallel with the shears.

To test the carriage cross shears at right-angles to the spindle: Take a very light cut over the large face plate and test with a standard straight edge. If perfectly plane, the alignment is correct. If the face plate is perfectly true and it is not desirable to take a cut over it, a smooth ended tool held in the tool post can be brought up to the face of the plate, near the centre, just close enough to pinch a piece of paper lightly. Now move the rest out to the outer edge of the plate without allowing the tool or carriage to shift along the bed, and if the paper is still pinched to the same degree the alignment must be correct.

Assuming the face plate as true both on its face and circumference, to test the alignment of the tail spindle: Make a stub A to fit the tail spindle bearing as shown in Fig. 20. Bring the spindle back until the tail screw starts to expel the stub centre A, and so adjust the screw that when A bears against its point a smooth turning fit between A and the spindle bearing results. C is an arm passing through A and secured by the thumb screw B. D is a pointer which passes through the arm C and is held by the thumb screw I. Adjust the point E so it touches the upper surface of the circumference of the face plate at G. Next swing the arm around until point E comes on the bottom of the plate at J. If E touches at J with same degree of pressure as at G, then the tail spindle must be at the same height as the live spindle, and in like manner if it bears equally on the two sides of the plate the cross adjustment must be right.

In order to determine whether the centre line of the tail spindle is coincident with that of the live spindle we can reverse the point of D and bring F into contact with the face of the plate at H. If it maintains uniform pressure of contact while the arm C is revolved entirely around, then the dead spindle is central and parallel with the live spindle.

If the tail spindle has been set over for turning taper and it is desired to bring it back central, first set it as near to the correct position shown by the lines as possible, then place a long bar between centres, similar to the one shown in Fig. 19, and take a very light cut over the collars A and B without changing the transverse position of the tool. Caliper the diameters of A and B accurately. If they are not alike, make another set-over adjustment of the tail stock and repeat, continuing to do so until they caliper exactly alike. Two trials will usually be found sufficient.

To test the truth of the live centre, place a bar between centres and turn a small pointer up as close to the live spindle as the dog or driver will permit; then reverse ends with the bar and test the turned spot for truth of rotation. If perfectly true the live centre is running true. The centres in the test bars should always be carefully reamed and lapped or worn down to true surfaces.

It is difficult to keep the lathe centres in good condition and accurate work demands that they be so kept. The dead centre must be true and hard in order to wear well. The live centre need not be so hard, inasmuch as there is no wear between it and the bearing in the work. The live centre should be ground in position by means of a center grinder, such a device being shown in Fig. 21. After being ground the live center should be removed from its bearings in the spindle only when absolutely necessary, as it is practically impossible to put it back and have it perfectly true. A small prick punch mark on the nose of the spindle and a corresponding one on the center will enable the operator to put the center back as nearly as possible in its correct position. It is advisable, where nice work is to be done, to always grind the live center after it has been removed. The center should always be ground to an angle of exactly 60 degrees.

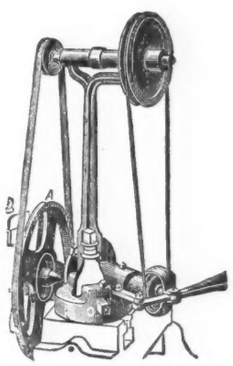


FIG. 21.

One of the first and simplest jobs the beginner does in the lathe is to turn a plain spindle. He can begin, even on this job, to exercise his judgment. For example, he is given a bar of round steel 2" in diameter and is to make a plain, straight and true spindle 1⅞" diameter by 2 feet long. In cutting this bar he must make the necessary allowance for squaring up the ends. If cut in a cut-off machine, 1-32" will do; if in the power hack saw 1-16" should answer if the saw is running reasonably true, while ⅛" or even ¼" would usually be required if haggled off in the blacksmith shop. Having cut the bar and made the required allowances in length, he next centres it with punch and hammer. As a beginner he must use the caliper dividers or "bell centre"

punch for finding these centres; but as he becomes more experienced he finds for work of small diameter, at least, that his eye is quite as good as either of these tools. If he is in an up-to-date shop he centre drills the ends with a combination drill and centre reamer, which makes them look about as shown in A in Fig. 22. He now squares off the ends with a side cutting tool, and how easily he gets them square to the very centre by slacking back slightly on the tail spindle and allowing the tool to cut into the centre. He must be particular about getting the bar to exact length in this operation, and when finally to length the ends must look as shown at B in Fig. 22. To leave an end as shown at C Fig 22 is unpardonable, even on the roughest kind of work. When left as shown at B a reliable centre can be had at any time should it ever become necessary to place the spindle between centres again.

He should next rough to within about 1-32" of the finished diameter for a length of from three to four inches from the tail centre. In doing this the centre bearing at that end becomes worn down to a nice, true bearing. The work is now changed end for end and the balance first roughed down and then finished. It should be here noted that no part of the work should receive its final finishing cut until it has all been roughed over. The reasons for this are, first, that the centres should be worn down to true bearings, and second, because of the springing due to removing the fibre strains in the metal. If a part be given the final finish before the balance is roughed down, that part will usually be found out of true after the last roughing. Not only is this the case with the rolled metals, but with the cast as well, where the removal of the skin or scale usually causes the work to change somewhat in form.

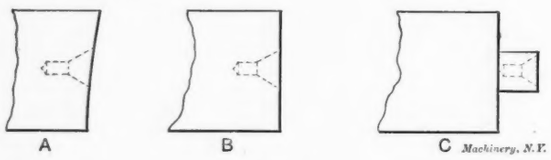


FIG. 22.

The required quality and truth of the finished surface must determine the number of cuts to take. For the roughest work a single cut will frequently do, and for general work two cuts, the first a roughing leaving only enough for a finishing cut. The latter cut should always be a light one. When a very nice, true surface is desired three cuts are advisable; a roughing, a sizing and a finishing cut.

In turning the above bar the young mechanic should learn a lesson in cutting speeds. Mild steel can be machined at from 20 to 30 feet cutting speed per minute, depending on its hardness. The beginner usually runs way below speed, and as he has no experience upon which to base his judgment in speeding the work, he should make a simple calculation in each case until his eyes tell him the proper speed without figuring it.

As the circumference of the work is approximately three times the diameter, he would in the present case have the work moving to the tool about six inches per revolution. At a cutting speed of say 25 feet per minute, the work should make about fifty revolutions per minute. Chalking a spot on the face plate and counting the revolutions will determine quickly whether or not the speed is correct.

This matter of speed is of very great importance, not only in its effects upon the output of the lathe, but upon the workman himself, as he quickly becomes tuned with his machine and loses that snap and vigor at his work which comes from seeing everything move along at a quick, business-like pace.

The young mechanic should familiarize himself at the beginning with all the details of construction and manipulation of the lathe itself. He will necessarily do work slowly at first, but he must learn accuracy from the beginning. The speed will come as he improves in skill and gains in confidence.

He must learn early the power of the machine, the strength and wearing qualities of the cutting tools and the strength of the materials upon which he operates. He will then not overtax the machine and break or injure the tools and work; neither will he take three cuts over a piece of work when two would have answered quite as well.

If the surface is to be a polished one, he must make some allowance for filing and finishing with emery. This is a matter of judgment, and the beginners judgment is usually poor, as he leaves altogether too much to remove with the file, which takes up time and injures the true of the work. It is very difficult to file much on rotating work and keep it cylindrically true. The finishing cut should therefore leave the surface smooth, true and within one to five thousandths of finished size, depending on the degree of accuracy required.

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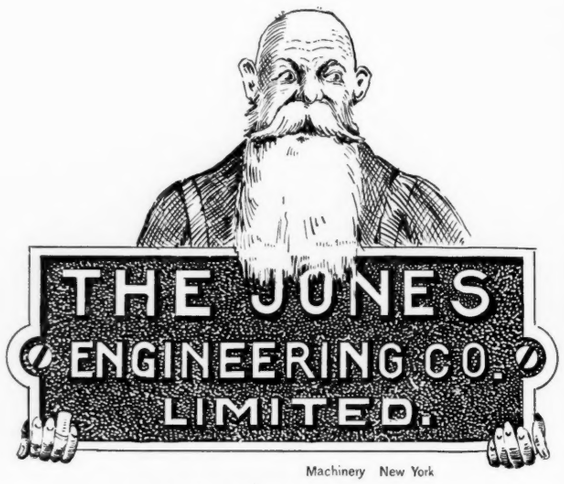


CHAPTER II.—A BLOW-OFF.

The next morning everybody was hustling at the works, when in walked a pompous looking gentleman, the proprietor of a woolen mill of considerable importance and the men at Jones' felt it their duty to maintain the dignity of their concern. The "cub" seized an oil can and began to oil up promiscuously; he oiled the loose pulley to make it slip and he oiled the belts to keep them from slipping, and as the grindstone was out of water he oiled the surface of that. He was "showing off." The blacksmith, "clad in a little brief authority," fired off orders to his striker loud enough to be heard out in the yard. He was "showing off." Young Jones "showed off" by running hither and thither with his hands full of tools and making a good deal of the fuss and splutter that insect authorities delight in. The "old man" fell to "showing off," delivering decisions and discharging directions at whoever came his way and above all the visitor beamed a majestic and condescending smile on the little shop and warmed himself in the glow of his own grandeur. He, too, was "showing off." "Mr. Jones," said he, "do you understand the mechanical construction of a safety-valve?" "Safety-valve, why sir, I was brought up on a safety-valve! I've made 'em for all sorts of purposes; made one for my wife to put into a pie to keep it from running out!"

Without noticing the flippant interruption the great man invited Jones over to his mill and on the way he explained that he was making some changes which necessitated running a steam-pipe right where the lever of his safety-valve came, yet for several reasons he did not wish to move the valve, and he wished for Jones' suggestions. After studying the situation, Jones delivered the following decision. "Now you see, sir, it's like this: them levers is governed by a principle and if ye understand that principle you can do pretty much anything with them. We calls it the principle of multiplication; it's kind of a doctrine of long arms and short arms. This lever you say is in your way. Now if we take the long arm of it and bend it right up into the air where there is more room it ought to multiply just the same, provided we don't change the length of the arm, d'ye see, sir? Well, then we can run a rod across the boilers and hitch to a bell-crank and use the same balance weight you've got a'ready, and I can hitch it into the right notch first time trying; if I don't, I'll eat it!" This argument seemed so plausible that the mill owner told him to go ahead, and before the next morning the rig was in place as shown in Fig. 5.

Jones went down early to visit "Mac," the Scotch engineer, and see how he liked the arrangement. "Mac," said he, "What was the safety-valve set to blow off at before we changed the lever?" "A hoondred poonds," Mac replied.

"Fire her up Mac and let's see her blow off. When I get a thing all figured out as well as that I like to see it work."

"Seventy poonds," called out the engineer as though he was a pilot taking soundings. "Smart trick that," Jones continued, "The old man was afraid we would have to move the valve, but I showed him a way worth two of that.". "Seventy-five," sung out the Scotchman, who was watching the gauge more intently than he was the story. "Oh, never mind the small change," Jones exclaimed, "run her up to par. I didn't spend half the night setting your old safety-valve at any fractional denomination. When she reaches a hundred, she'll blow off and not before." "Eighty pounds," the hand of the steam guage quivered, there came a pop and a swish and the valve was blowing off!

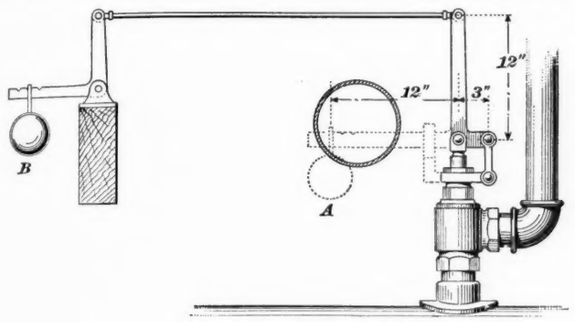


FIG. 5.

The expression on Jones' face changed from astonishment to incredulity, then to disgust and he started for home to try and figure out the mystery—why with the same valve and the same weight and the lever arms the same length as before the valve should blow off at 20 pounds less indicated pressure. As for Mac, he showed his contempt for all such trappy devices by remarking, "These domd Yankees think they are so smart that they can tak a paper o' pins and improve on the steam engine. Eh, mon, if Stevenson had only lived!"

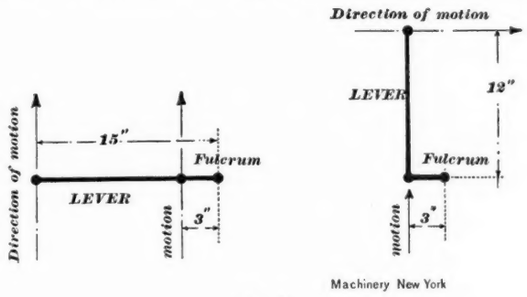


FIG. 6.

It will be seen by those who followed the articles on levers in MACHINERY a year ago that our friend the "old man" deceived himself when he bent the lever at right angles. While it was still subject to the same laws as before he failed to understand those laws. The length of the lever should be measured at right angles to the line of motion and the lever which multiplied five times when straight only gave a multiplication of four when bent. W. H. S.

* * *

"If a young engineer is so situated that he can contribute to the technical press as a writer it will be of distinct advantage to him to do so. He acquires the ability to express himself well; he learns to think straight (or he is quickly found out); he will become known to his future clients. The discussion which may arise on the subject will be at comparatively short range because publication is not delayed for weeks or months; an inexperienced writer is given a better chance to consider any reply to questions and criticism than is offered in oral debate at a society meeting; moreover, the men who take part in such discussions do so because they are interested in the subject. Lastly, the pecuniary reward is not to be despised."—Daniel Royse in "Purdue Exponent."

* * *

A great forging press of 10,000 tons capacity has been built for the Dillingen Iron Works, Germany. While this is an immense machine, America still holds the lead, for the press at Bethlehem, Pa., is of 14,000 tons capacity.

FAMILIAR SUBJECTS IN MECHANICS.—5.

BELTING AND PULLEYS (Continued).

SAMUEL WEBBER.

I thought, when I began, that two letters would exhaust all I could find to say on the subject of pulleys and belting; but I find that I have as yet omitted to call attention to the especially important factor on which the transmission of power by such methods depends; that is, the "coefficient of friction." There appears to be some difference in opinion among various writers as to what this is, how great it is and how to ascertain it, and I will therefore explain my understanding of "what it is" in the first place. I consider it to be the amount of the power applied to a shaft by the friction of a belt on the surface of a pulley which that shaft will deliver at some other point, either to another belt, or to a train of gears, or in any other manner. That is, if 10 horse-power is applied to the surface of a pulley, and the shaft delivers 5 of it at some other point, the "coefficient of friction," or the proportion realized, is 50 per cent., or 0.500, as expressed in decimals. Morin gave it as his conclusion, from the result of his experiments, that 50 per cent. could be thus obtained, and the experiments of Messrs. Briggs and Towne, published many years since, gave it as 42 per cent. Now while, as the experiments I have been recording show, I have obtained a coefficient of over 50 per cent. under favorable circumstances, I am inclined to fall back on the results of Messrs. Briggs and Towne, and adopt 42 per cent. as a safe and reliable factor.

To illustrate this point, I will refer to the tests of the flexible "Schutz" belt, on page 382 of MACHINERY for August, and first take up the test of this belt on iron pulleys with a brake load of 160 lbs.., a belt speed of 667 feet per minute, and a slip of 2 per cent. I allow this slight slip, because all other writers have done so to the best of my memory.

Now the initial strain on this belt was 83 1-3 lbs per inch, or 1,000 lbs on 12 inches. As the strain was equal on each side, the pulley received twice this, or 2,000 lbs., and this multiplied by 667 feet per minute, gives 1,334,000 lbs., one foot per minute, or 40.4 H.P. applied to the surface of the pulley. The brake power realized from the shaft was 16.69 H.P., and dividing this by 40.4, we get 0.413, as the "coefficient of friction," as stated in the tables. When applied to the wooden pulley, with a brake load of 180 lbs., and the same tension, we got, at 691 feet belt speed, 19.80 H.P. without any slip, and a coefficient of 47.1 per cent. With 3 per cent. slip we obtain 48.5 per cent., and finally, by increasing the load, attained 61.2 per cent., without apparent increase in slip, and a total power of 26.16 H.P., which practically exhausted the engine.

This, however, was an exceptionally soft and flexible belt, and as the new "Hoyt" belt, of regular manufacture only gave .420 when applied flesh side to the pulley, or exactly Messrs. Briggs and Townes figures (see p. 381). I feel disposed to recommend that as a standard.

Some writers on this subject have given much higher coefficients of friction, as the result of their experiments, even reaching over 100 per cent., but as that is a mechanical impossibility, like the old story of the man "who lifted himself over the fence by his bootstraps," such statements only vitiate all their conclusions and reported results.

One of the recent papers read before the American Society of Mechanical Engineers, recommended a speed of 12,000 to 14,000 feet per minute for the transmission of one horse-power by each inch in width of a double belt, but the experiments from which these figures were deduced were evidently made with narrow machine belts, probably laced, on heavy tools, and with the idea of making the belts last as long as possible and do not represent the real driving power of a belt. I see no reason to alter the figures I published many years since and gave Mr. J. H. Cooper for the first edition of his "Notes on Belting:" viz., that 600 feet per minute for a single belt, and 400 feet for a double one, was sufficient velocity to enable each inch of width to convey one horse-power.

These figures were based on the experiments of Morin, Briggs and Towne, Kirkaldy, and many others, on the strength of leather, and are applicable only to what may be called "permanent belts," *i.e.*, belts cemented at the joints, and running constantly in one position. The figures I have copied in these articles will prove the correctness of these estimates, and are fully corroborated by over half a century's experience among belts and pulleys.

It may be well to state, also, that I call the thickness of a single belt, from 1-6 or 3-18 of an inch, to 3-16 inch; of a light double belt, ¼ inch, and a heavy double belt ⅜ inch, and I may say, also, that I have known a heavy double belt transmitting over 600 H.P. for many years, at a speed of less than 300 feet per minute, for each inch horse-power."

When it comes to a question of narrow machine belts, I do not pretend to be governed by these rules, as the strength is then only that at the lace holes. In such cases I add 50 per cent. to the necessary velocity, and when stopping and starting up again are frequent, or the belt is often "shifted" from fast to loose pulleys, and "vice versa," I should advise doubling it, as the strain of starting up a machine to speed from "dead-rest" is very much heavier on the belt than that required to keep it in constant motion afterward. Belts should always be kept flexible, without being allowed to get "greasy," and there are various good dressings on the market for that purpose, the basis in general being neat's-foot oil, stiffened with a proper proportion of beeswax and resin, and applied with a brush "luke warm," or just warm enough to soften the stiffening, and well rubbed in. Hot oil of any kind should never be applied to a belt, nor should the surface be left damp or slippery. I have known large main belts in some of the cotton mills on the Merrimac River to do their work satisfactorily after 40 years of service!

I find on looking over what I have written that I have omitted to protest against the too common use of too narrow double belts. There are cases, such as on the cone pulleys of some heavy machine tool, where they may be advisable to economize weight and space in the head-stock of the tool itself; but I am decidedly opposed to the use of double 3 and 4-inch belts when there is width enough available to use a 6-inch pulley, and a single thickness of leather. A 6-inch belt, 1-6 of an inch thick, is as strong as a 4-inch belt of ¼ inch thickness, has a better hold on the pulley, and will usually outlast its lacings. A reference to what I have before said will show that there is less "disintegration" in the body of a single belt when used on a small pulley than in a double one.

I think this covers all I want to say in regard to belts and pulleys, but if I have omitted any points on which my readers desire information, I shall always be happy to give it to them, if I possess it myself.

There is another mode of pulley transmission now coming extensively into use, commonly known as "rope driving," which next calls my attention. Although useful in certain cases, and for certain purposes, which I will specify hereafter, I cannot admit that for steady, regular transmission in ordinary cases, when the distance from shaft to shaft is not over 40 feet, and the shafts are in parallel lines, it has any advantage in the point of economy over flat leather belts. It is true that the first cost is much cheaper than that of leather, but the durability is also much less, and as I have previously stated, I have known good leather main belts doing effective service after 40 years' constant use.

The use of a round cord or string, for the transmission of power to a spindle, is as old as history, and probably far antedates the use of a flat "strap," as our English cousins still call leather belts. They have always been in the habit of transmitting large amounts of power by shafts and gears, and never took kindly to the use of leather main belts, which were first introduced, to the best of my knowledge, by Paul Moody and Sam'l Batchelder in Lowell in 1828. When, however, rope transmission was fully established by "Hirn" in Germany, and its great advantage over shafts and gears fully shown, the English mill owners "tumbled to it" at once, as it did not shock their insular prejudices by being a "Yankee notion," and American visitors to English mills and shops, seeing its greater cheapness of first cost, soon introduced and recommended it in this country. For long reaches of over 40 or 50 feet, the superior lightness of a "rope drive" is no doubt a great advantage. It is also available for outdoor transmission, where exposure to the weather would render a leather belt impracticable, as the same composition which is applied to the ropes to keep them from wear on the surface also waterproofs them against damage from the weather. To my mind, however, the particular advantage which they offer is their adaptability to "drives" at any angle. There is no need of parallelism in the shafts, and by the use of properly situated "idler pulleys," the shafts may be used at right angles with each other if necessary.

The great difficulty which the writer has noticed in their use has been the tendency to use too small pulleys, and by referring to his previous remark in regard to the difference between calculated and actual speeds, caused by the thickness of belts, the source of this trouble will be seen at once. Let us take a 40-inch pulley, for example, which is the smallest size admissible for a one-inch rope. The length of its semi-circumference is 62.83 inches, which is the distance the inner surface of the rope would have to travel in going half round it. Now the outer surface would have to move the distance of the semi-circumference of a 41-inch pulley, or 64.40 inches, a difference of over 1½ inches at each revolution, and then as they came back to the stretch between the pulleys, both would have to recover their normal positions, or the inner surface would have to stretch ¾ of an inch, and the outer one contract the same at every revolution. Is it any wonder that driving ropes wear out and disintegrate under such conditions? This is especially the case with regard to Manila rope, each fibre of which is a congeries of finer fibres, united by a natural glue, and while the torsion of original fibres in the rope reduces the action of the strain from a direct lineal one to one of axial compression to a great extent, and the "dressing" applied to the ropes also tends to preserve them, the destructive action is there, all the same, and this is the reason why Messrs. C. W. Hunt & Co. and other makers of "rope drives" insist that no pulley shall be used of less than 40 diameters of the rope. I have seen cases myself where one-inch rope carried at high speed over a 24-inch "idler," has gone to pieces in 36 hours! With thin leather the case is different, and therefore, for very small pulleys I still recommend leather belting, as thin as possible.

* * *

WEATHER WAS TOO DAMP.

Editor MACHINERY:

I send you herewith a clipping from one of the Harrisburg (Pa.) dailies. If you see fit, you may explain in the columns of MACHINERY "what sort of brasses these may be."

V. E. SHOPE.

The Clipping.

Two more of the big "H-6" engines went through the city at an early hour yesterday morning on their way to a western road. The first to arrive in this city was the 1823 and it was only with great difficulty that it reached the roundhouse. The brasses of the oil cup were found to be warped and the oil would not lubricate properly. When the engine reached this city the journals were very hot. The engine went on, however, to Altoona, where it will be put in the shop for new brasses. No. 1824 followed several hours later, but was in first-class condition.

* * *

A COMPARISON OF MOTIVE POWERS FOR AUTOMOBILES.

The great interest manifested in the evolution of automobiles makes the presentation of the following comparison of motive powers for these vehicles, by A. Fischer, in the first issue of the "Automobile," timely. How much of personal bias enters into the conclusions, the reader must judge for himself.

"Commercially, we need at present to consider but three systems of mechanical propulsion of road carriages—the electric, the steam and the gasoline engine. We read a great deal in the papers concerning the compressed air, carbonic acid-gas and liquid-air motors, but as yet nothing has been demonstrated in regard to them, except the ability of the promoters. The electric system is now being pushed by ample capital, has been extensively tried in this country, and we shall soon see whether it is destined to meet with success or failure in the limited field in which it can be applied.

"The steam carriage is now also being brought rapidly to the front. Aside from any questions of merit in this system, the laws of most states do not allow steam carriages on the streets of cities. The gasoline carriage has not as yet been pushed to the extent the system deserves, although it is the system that has made the automobile a success. In France the gasoline automobiles outnumber all others about 100 to 1. They are the only ones that have so far been successfully used for touring. It is the opinion of the writer that this will soon be so in this country. Below is given a synopsis of good and weak points of these systems.

"A short synopsis of the advantages and disadvantages of each system:

ELECTRIC STORAGE BATTERY SYSTEM.

Advantages.

A rotary motor.
Absolutely no vibration.
Transmission of power from motor axle simple.
Easily manipulated.
Can be handled by almost any one with a little practice.
No heat.
No odor.
Motor can run in either direction at almost any speed from 0 to 1,000.
Driver can start carriage without any preparations.

Disadvantages.

Its limited range of action being about 20 to 40 miles radius from source of supply hence can only be used in large towns with a number of central supply stations.
Excessive weight of batteries, being out of proportion to load carried.
Lack of economy, being the most expensive of all systems.
Short life of batteries.
Cost per mile on pleasure carriage about 5 cents.

STEAM.

Advantages.

Little vibration.
Transmission of power simple.
Weight moderate.
No central station required for charging.

Disadvantages.

Dangerous on account of the pressure in boiler.
Dangerous on account of use of liquid fuel used to heat boiler.
Boiler easily ruined by impure water.
Difficulty of management, requiring an engineer.
Discharge of steam on starting (frightening horses).
Length of time required to start—getting up air pressure, lighting torch to heat burners in getting up steam pressure.
Difficulty of keeping up enough steam pressure to supply engine.
Odors from imperfect combustion of oil.
Cost of operation about 3 cents a mile.

GASOLINE.

Advantages.

Absolute safety.
No fire for engines.
Moderate weight in proportion to load carried.
Economy of fuel, about one-quarter as much oil being consumed for horse power as in steam.
The only system having an unlimited range of action. Gasoline and water can be carried sufficient for 300 to 500 miles' run. Can be used anywhere. No especial knowledge required for management.
Cost of operation about one-half cent per mile.

Disadvantages.

Some vibration.
Motors must be started by hand.

[To these disadvantages must be added: A variable speed device is required and engine must usually run when carriage is stationary. Also, a slight odor.—EDITOR.]

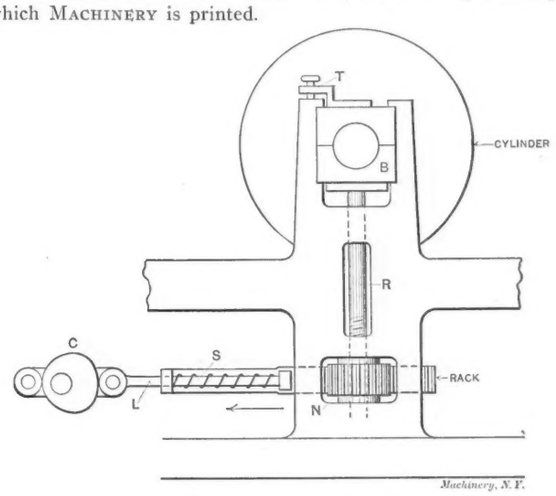
* * *

A NOVEL MECHANISM.

There is no class of machinery better adapted to the study of the principles of mechanism than printing machinery. The motions that must be produced to ensure even impression of the paper on the type, the feeding and delivery of the paper, and the distribution of the ink; and the various other movements that must be accomplished, require such a multitude of cams, levers, gearing trains and other devices that the student will here find enough material for a long course of study.

Presses used for the best book work are of the type known as two-revolution presses. Their chief elements are a flat bed, on which the form of type is placed, and a cylinder around which the paper passes as it receives its impression. The bed travels back and forth under the cylinder once for every two revolutions of the cylinder and the latter always rotates in one direction. When the bed moves forward in the direction in which the cylinder is turning, the paper is printed and when the bed returns the cylinder raises out of contact with the bed so that there will be no interference while the motions of the two are in opposite directions.

It is a neat problem to design a motion that will raise and lower the cylinder at the proper times, since it must be held with absolute rigidity when in its lowest position, ready for the impression. The neatest solution to the problem that we have seen is that shown herewith, which is used on the presses upon which MACHINERY is printed.



CYLINDER RAISING MECHANISM.

The cylinder journals run in boxes, one of which appears at B, which are free to slide in a vertical direction between the jaws of the frame. The box is raised or lowered by a rod, R, which is threaded at its lower end for the nut, N. This nut is in the form of a pinion or small spur wheel, which bears top and bottom in the slot shown in the frame and is rotated back and forth by the rack R. The rack is operated through the rod L and the spring S by the positive motion cam C. Suppose the cam to move the rod L in a left hand direction or in the direction of the arrow. The pinion N will then turn in a left hand direction, as seen from above, causing the rod R and the box B to move downward until the thumb screw T comes in contact with the top of the frame. This prevents further motion of the rod R without breakage and the spring S then comes into play, stretching as much as is necessary to allow the cam to complete its rotation. The result of this is that while the cylinder is always locked rigidly in position by the nut, N, its motion can still be easily adjusted by the thumb screw T.

Most mechanisms used in printing presses for this purpose require a lengthening or shortening of the rod R in the adjustment of the cylinder, but in this case this source of inconvenience is avoided by the very ingenious combination of the nut N and the spring S.

* * *

LOCOMOTIVES USED AS "SLUGGERS."

An English paper says that the locomotive as a weapon for assault and battery promises some novel situations to the novelist in search of new color for a thrilling work. At the Cyfarthfa Steel Works of Crawshay Brothers, near Merthyr Tydfil, are some locomotives having quite cantankerous engineers. The other day, one of the engineers, named Hopkins, left his engine to get coal. While thus engaged another engineer, named Edwards, came along and requested that the first locomotive should be moved away so that he could pass over the crossing to a water tank. Receiving refusal, he attempted with his engine to move the obstructing locomotive, whereupon Hopkins mounted to his place, put on steam, and drove the aggressive engine back. The latter then charged forward, but, according to the police court report of the subsequent proceedings, got the worst of it. A third charge, however, resulted in the engine driven by Hopkins being sent off the rails. Hopkins has been committed for trial for endangering the safety of the public, his defence being that he did not commence the battle. But there was a conflict—of a kind very unusual.

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OCTOBER, 1899.

CIRCULATION STATEMENT.

The regular edition of MACHINERY for October is 17,500 copies, AMERICAN MACHINERY is the title of the foreign edition, printed on thin paper and comprising all the reading and advertising matter in the domestic edition. No subscriber is entered on our mailing list until his subscription is paid for, and all subscriptions are stopped at expiration. No papers are sent free except to advertisers, exchanges and circulation agents

The circulation of the three leading papers in the machinery trade, so far as it is possible to obtain the figures, is as follows:

The IRON AGE, about	7,000
The AMERICAN MACHINIST, about	12,000
MACHINERY	17,500

Owing to a typographical error, the run for September MACHINERY was stated to be 17,150 copies. It was 18,000.

* * *

TECHNICAL PAPERS.

One of the serious drawbacks with machinists to-day is that they are tied down, not only to one town or perhaps one shop, but oftentimes to one part of one shop, and it is not always easy to make a change for the better. It is expensive to branch out and try experiments, and if it were not for the technical press too many would find that they were gradually growing out of touch with all that was modern and progressive. This is one reason why every mechanic should make it a point to read a mechanical paper. It will help him to advance, to get out of a rut, and to broaden his knowledge beyond the narrow horizon of his own experience. How many mechanics are there who could visit, even a single one of the great plants of the country like the famous Union Iron Works of San Francisco, which were illustrated in the last number of MACHINERY, or the works of the Bethlehem Steel Co., photographs from which appear in this number of the paper? How many are there who, even if they did visit shops like these, could have pointed out for them the novel and improved methods and could take notes for future reference?

Glancing through the files of MACHINERY, we estimate that not less than 1,000 shops in this country, Canada and Europe, have been visited by the editors or other representatives of the paper during the past five years for the preparation of articles; and there have also been hundreds of communications from readers upon practical shop experience. While much of this matter is not new to every mechanic, it is inevitable that some of it must have been new and of value to all. It is impossible for any one man to acquire in his own experience a knowledge of the methods and devices that have been developed only by the work of hundreds of men in different parts of the country. A mechanical paper must necessarily cover a wider range of work than one man is engaged upon. A man may, for example, be employed during his life time in engine building and have nothing whatever to do with the finer grades of tool work, or even with any other class of heavy machine construction. He would grow to be a very narrow and one-sided mechanic, however, if he sought only to obtain information that would assist him directly in the building of engines. The only way to become a mechanic with all-round good judgment and with the ability to take responsible positions is to become a many sided man as far as it lies in one's power to do so. No information can be absorbed from any source that will not be of indirect benefit in conducting one's special line of work. There is probably no factor so essential in making a well balanced mechanic of this description as are the technical papers. The thoroughness with which most of them do their work at the present time makes them indispensable to all who wish to advance in any department of machine construction.

* * *

IRON VS. STEEL.

It is probably within the remembrance of even the younger readers of MACHINERY that the discussion as to the relative merits of wrought iron and steel for shafts, axles, crank-pins, etc., was conducted in nearly every technical paper. There was at that time a very good reason why there should be so wide a difference of opinion regarding the merits of these two materials.

Wrought iron is a ductile material that is easily forged, and when it is properly forged, it gives good results in actual service. It has an elastic limit of about 22,000 pounds and a tensile strength of 50,000 pounds.

At the time when steel was introduced commercially for forgings, it was made to conform as nearly as possible to the figures obtained with the best wrought iron, and as considerable difficulty was experienced in forging high-carbon steel, specifications usually called for a mild, ductile material of perhaps 60,000 pounds tensile strength and 30,000 pounds elastic limit, with an elongation of from 25 to 30 per cent.

Steel of this character is superior to iron for most forgings, but, as stated, it is not strange that there was a diversity of opinion as to the relative merits of each material. With the improved methods of steel manufacture, however, came the successful attempts with higher carbon steel and later with nickel steel, with the result that we now have forgings of both large and small sizes with a tensile strength of 80,000 pounds, an elastic limit raised to 50,000 pounds, and an elongation nearly as great as that obtained with the milder steels.

It should be borne in mind that what is desired is not so much a steel of high tensile strength, as one with a high elastic limit combined with ductility or toughness. When steel is strained beyond its elastic limit, the point of safety has been passed. Prof. Mansfield Merriman, of Lehigh University, has calculated that the shaft of the United States Steamship Brooklyn, which is 17 inches outside diameter and 11 inches inside, is as strong as a solid shaft of milder steel about 19 inches in diameter. This shows in a striking manner that there seems to be no longer room for argument as to the merits of high and low carbon steel or of wrought iron for important forgings.

* * *

A congress of specialists of all countries for the purpose of obtaining uniformity in the methods of testing materials of construction, is to be held, under the patronage of the French Government, during the Paris Exposition of 1900, from the 9th to the 16th of July. The unifying of testing methods is a question of great importance, and its solution is indispensable if, from the testing of materials, exact and incontestable results are to be expected, giving every possible guarantee.

AMONG THE SHOPS.

SOME NOTES ON THE MANUFACTURE OF HYDRAULIC MACHINERY, GATHERED IN THE SHOPS OF THE WATSON-STILLMAN CO.

The manufacture of hydraulic tools and machinery is properly classed as a separate business from ordinary tool manufacturing, as the peculiar conditions encountered in the constructon of machinery that is required to withstand an internal pressure varying from 6,000 to 30,000 pounds per square inch according to the service, call for methods and expedients in shop practice that are somewhat out of the ordinary.

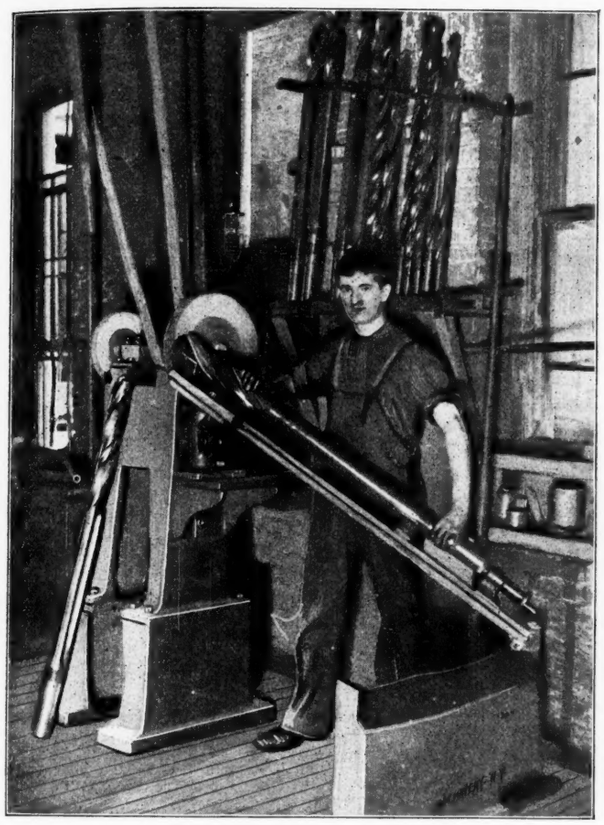


FIG. 1. GRINDING SOME HUGE TWIST DRILLS.

One of the well known firms that have for many years been engaged in the manufacture of hydraulic tools and appliances, is the Watson-Stillman Co., at East Forty-second street, New York City. Here in the heart of the city and in a rather small space when the extent of the business is considered, the writer found a shop that manufactures nearly seventeen hundred different tools, many of which, however, are built to order only. Nearly all of this large variety involves in some form an application of the displacement principle for obtaining heavy pressures and range from tools weighing a few pounds to presses weighing tons and capable of exerting enormous pressures. One of the notable tools in construction at the time of the writer's call is a draw-bench for the manufacture of seamless steel tubing which is over eighty feet long when the piston is extended. The limits of the shop do not permit the complete erection of this machine, but as the parts are made on the interchangeable plan, the complete shop erection is a minor matter. A cylinder of the length required by this tool is necessarily made in sections and the form of coupling used is shown in Fig. 2. The essential features of this novel form of coupling are clearly indicated in the cut, the ends of the sections having flanges beveled as shown at D over which fit the two halves of the clamp B B. The interior of these pieces is bored out to fit the tapered flanges and when drawn together by the bolts C C, the ends of the cylinder sections are drawn squarely together with a uniform pressure on all points of the joint which obviously is of great advantage when holding back heavy pressures.

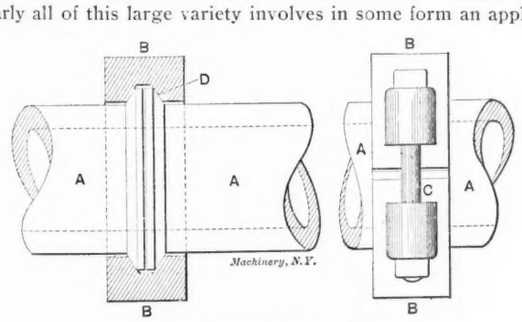


FIG. 2. HYDRAULIC COUPLING.

The piping and fittings for this and other presses are all tested hydraulically to a minimum of 6,000 pounds per square inch, and as much higher as the service may demand. The fittings are all steel castings and are threaded right and left as it has been found to be the best practice, which will undoubtedly rather overturn the ideas of many pipe-fitters who have a prejudice against the right and left forms of fittings.

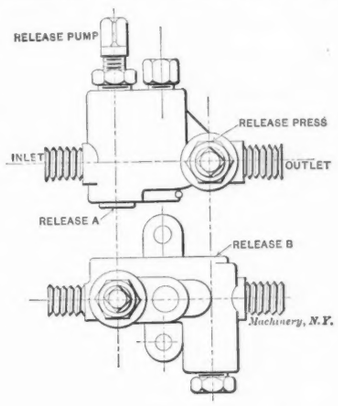


FIG. 3.

All materials entering into the construction of hydraulic machinery and tools must be of the best, especially when intended for heavy work. To obtain bronze castings which are uniformly free from porous places seems to be very difficult, and it becomes necessary in consequence to test the piece as the different operations are performed. The parts referred to are the pumps, valve cases and other fittings of a similar nature. While many of these parts, such as Fig. 3, are of a complicated nature as to the cavities and passages, it has been found most practicable in most instances to have such parts cast solid and then to machine out the various holes and valve cases from the solid metal. The practice is to test the part after each operation for porosity, and very often when the last operation is concluded, the final test will disclose a flaw that necessitates the condemnation of the part. It is not surprising, therefore, that hydraulic machinery and tools bear what might be thought to be a high price as the unavoidable losses from such failures have of course to be made good by an increased selling price.

One of the most striking features of this shop to the machinist is the use of abnormally large twist drills for chucking machine work. The grinding of one of the largest drills shown in Fig. 1, will give a better idea of the size than the dimensions, which are 3½" diameter by 4' long. As will be noted, these drills have oil conduits for carrying lubricant to the point of the drill, and provision is made in the machine in which they are used for a large supply of lubricant so that the temperature of the fluid may be kept at a low degree. The efficiency of these drills may be judged from knowing that over 300 cubic inches of mild steel have been drilled out in one hour. This involves a depth of 32" with a drill 3½" in diameter. Such a performance is, however, nearly double the regular rate, as the extra grinding and wear does not warrant it from an economical standpoint. The smaller hydraulic cylinders for the jacks and similar tools are drilled from the solid material, for although it is possible to obtain seamless tubing that may be superior in some respects to cylinders made from the solid, the cost is greater and the supply more or less uncertain.

The interior of the tubes is ground on a grinding machine which is worthy of notice, as it embodies a principle that is not used, to any extent at least, outside of this shop. The machine is built on the general lines of a lathe and the tube or cylinder to be ground is given a longitudinal movement by a carriage having two steady-rests which hold the work. Mounted in the spindle

is a long supplementary spindle D, about 1½" in diameter, which carries the grinding head shown at C in Fig. 4. The head has three slots through which the pieces of emery stone A A project. The taper plug B and spindle are attached to the tail spindle by which the pressure of the emery pieces on the interior of the work may be regulated. The centrifugal action when the head is rotating at high speed is sufficient, however, to give quite a pressure, being ample usually for the finishing touches.

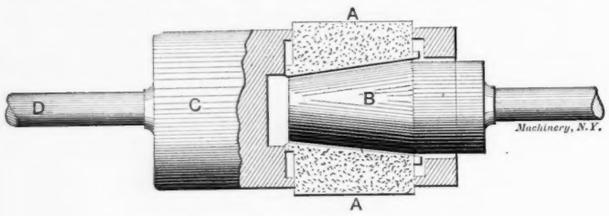


FIG. 4 INTERNAL GRINDING HEAD.

While boring machines of various types and makes are in use on the different classes of work, the boring of large steel tubes that require a smooth and accurate bore is done on an engine lathe which has been specially rigged for the purpose. This may be partially on account of the limited capacity of the boring machines at hand but the combination used in connection with the engine lathe is well worth a description, as by its use many shops may be provided with a good boring machine at a trifling cost. The work spindle has a hole large enough to allow the passage of the bar H, Fig. 5, which is about two inches in diameter. The bar is splined its entire length and is prevented from turning by a sliding feather attached to the thrust bearing. The feed is accomplished by a ratchet nut operated by the lever C, and the connection G which receive movement from a crank F on the end of the feed-rod. The thrust is taken by a ball bearing supported by the casting A, which is bolted over the back end of the head-stock. The tube being bored out is held in the lathe chuck and supported at the other end by a steady-rest, while the feed of the bar is toward the head-stock, thus putting the boring bar in tension as regards the effect of the feed. A packed bit is used with a constant stream of lubricant forced over the edges of the tool and another stream is directed on the bar at the head-stock to wash away the chips which collect in the threads and would clog the nut if allowed to remain. Provision has been made for a quick return of the bar when the end of a cut has been reached by slots cut in the nut and the end of the spindle which allow the insertion of a key, thus locking the two together. The ratchet being disengaged, the lathe is run backward at speed which rapidly forces the bar back through the spindle.

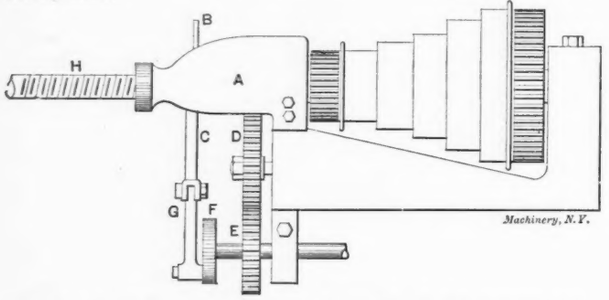


FIG. 5. ARRANGEMENT OF LATHE HEAD STOCK FOR BORING BAR.

The jack shown in the sectional cut Fig. 6 is reproduced from the Watson-Stillman catalogue, in which it is listed as a claw jack, but the essential features are the same in all the tools of this class, and in fact are practically the same in the other hand tools which operate on the displacement principle, as the great number of tools manufactured makes it necessary to have a standard form of construction for as many parts as possible. This being the case an explanation of the working of this jack will answer for practically all others of this company's manufacture, as well as those of other firms, with the exception of minor details. The writer has found in his experience that in many shops there is a surprising ignorance in regard to the principles and operation of these useful tools with a consequent helplessness when anything goes wrong with them.

Referring to Fig. 6 it will be seen that the piston or ram forms a reservoir for the liquid and that the lower part is a force pump for transferring the liquid to the lower side of the ram. The pump piston contains a valve with a long stem and the check-valve in the ram has a light coil spring which tends to keep it always to its seat. In operation the liquid in the reservoir is pumped into the space below the ram and as it cannot escape, the ram is pushed upwards with a force that depends upon the relative sizes of the ram and pump piston, the length of the lever and the effort expended by the operator. After the load has been raised to the desired point and the ram is to be lowered, the hand lever is turned over and forced to its lowest position. By this action the "lowering wire head," by reason of its eccentric connection to the arm, forces the sleeve downwards, which unseats the valve in the piston bonnet. As the piston is forced to its lowest position by the same movement, the projecting valve strikes the top of the check valve in the ram and allows the liquid to escape through into the reservoir and the ram to lower. It will be seen that there is nothing mysterious or difficult to understand in the operation or construction of a hydraulic jack, but they do require the best of materials in manufacture, good workmanship and some care on the part of the operator. The ram should be kept free from dirt, or if this is impossible, it must be carefully cleaned off before lowering into the cylinder to avoid scratching the bore. When necessary to replenish the filling, the liquid should be carefully strained before being poured into the reservoir. Probably the best filling for all around purposes is alcohol, as it will not freeze in winter or rust the cylinder. The practice followed in some quarters of using wood alcohol is condemned as its action is probably more detrimental to the leather packing than to the stomachs of the hardened characters who have been known to rob a jack of its life blood.

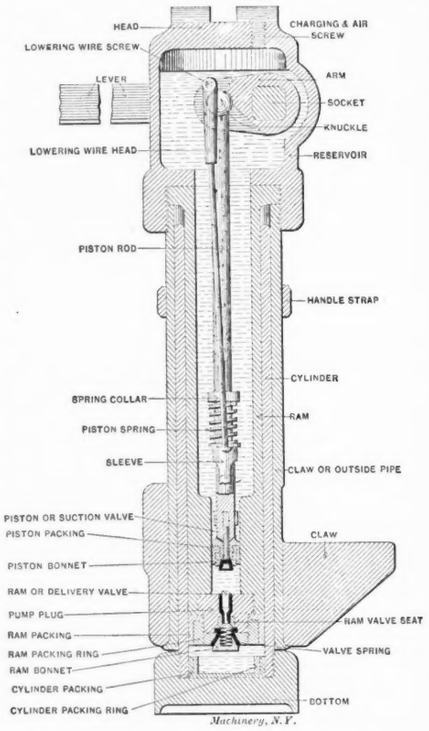


FIG. 6. DETAILS OF A HYDRAULIC JACK.

F. 1.	THE WATSON-STILLMAN CO. GENERAL INDEX.	Drawing No. D-122-134 Machine No. 1254

Name
Forging Press, 600 ton Hyd.
24" Ram, 4 ft. 0" stroke, 2500 lbs per sq. in.
Remarks
For 2½" and 5"—5 spindle Bal. Gov. Valve. See R-951-960

Color, salmon.

FIG. 7.

The efficiency and safety of a hydraulic jack depends on the tightness of the valves and the cup leather packings in the ram, so the manufacture of packings that will give the best results is quite an art. The writer was shown formed packings of various sizes down to as small as ⅜" in diameter. The latter were made from leather 3-32" thick and had a depth of ½", which gives one a new idea of the extent to which ordinary leather can be moulded.

A very good system is in vogue in the drafting room for the preservation of drawings, tracings and blueprints which also gives a ready means of reference to the drawing of any machine or part. The drawings which are 18″ by 27″ outside and 16½″ by 26″ inside the border line are kept in manila covers with the

THE WATSON-STILLMAN CO. DRAWING NUMBERS.	Drawing No. D–122 Machine No. 1254

Name
600 tons Hyd. Forging Press.
24″ Ram, 4 ft. 0″ stroke, 2500 lbs. per sq. in.
Remarks
.....
.....
.....
.....

Color, light blue.

FIG. 8.

distinctive titles and numbers of included drawings printed on the outside. For the safe keeping of the drawings and tracings, two safes are used, having sheet iron trays 19″ x 31″ x 1½″ deep. One of these trays is usually sufficient to hold all the

THE OLDEST IRON STEAMSHIP IN THE WORLD.

Of the United States steamer Michigan, on Lake Erie, which is the oldest iron steamship in the world, her commander, Lieutenant-Commander C. P. Perkins, gives the following particulars in "Cassier's Magazine" for September:

The vessel was constructed at Pittsburgh, Pa., in 1841-43; the parts were transferred to Erie, put together and launched on December 5, 1843. The original machinery, with the exception of the boilers, is still in her and in good condition. The vessel is an iron paddle-wheel steamer of 685 tons displacement; length of keel, 156 feet 4 inches; length between perpendiculars, 162 feet 6 inches; breadth of beam, 27 feet; depth of hold, 12 feet 5½ inches.

There are two inclined direct-acting engines. The paddle-wheels are of the usual radial kind, 21 feet 6 inches diameter, with 16 paddles, 8 feet long by 1 foot 4 inches wide. There are two steel boilers of the flue and return fire-tube type, 9 feet 6 inches in diameter by 15 feet 2¾ inches in length over all; two furnaces in each boiler, 6 feet 6 inches by 3 feet 6 inches in diameter, and have each a grate surface of 22.75 square feet. The total grate surface is 91 square feet, and the heating surface, 1,285

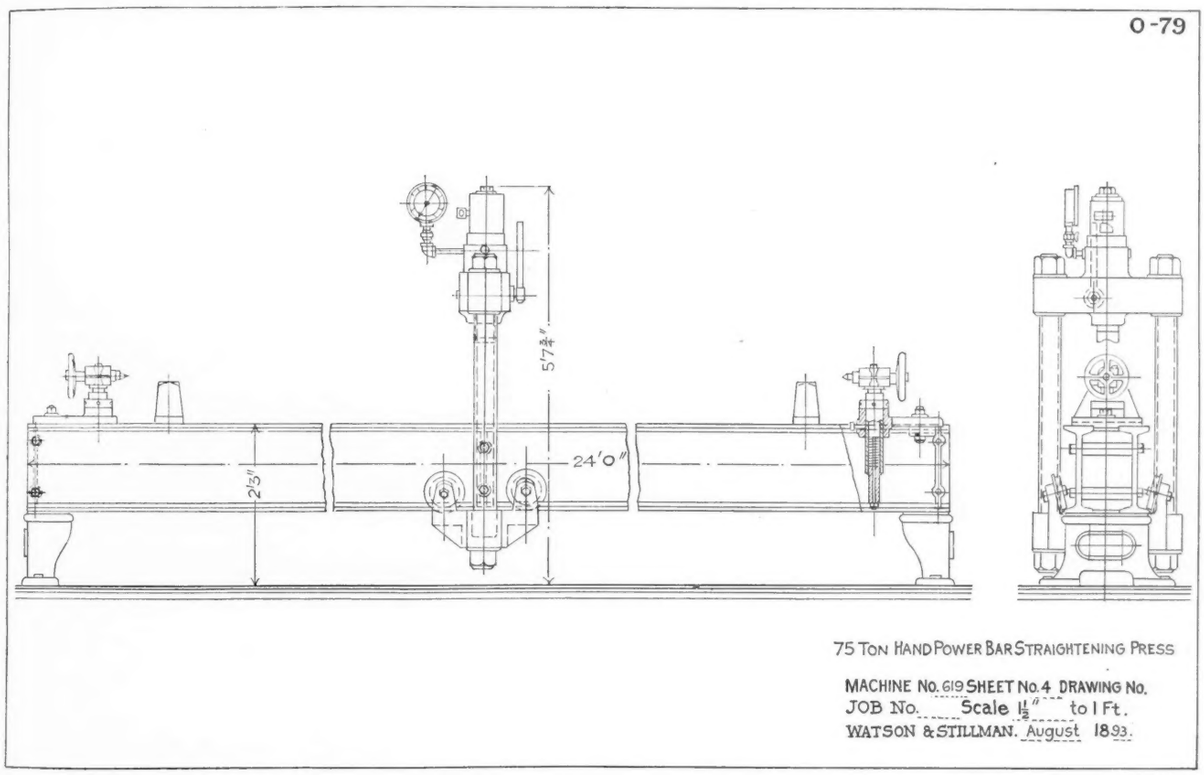


FIG. 9. FULL SIZE REPRODUCTION OF A SAMPLE BLUE-PRINT.

tracings of a class and have titles pasted to the front as "A—Plain Base Jacks," "B—Low Hydraulic Jacks," "C—Special Jacks," etc.

The card index system is used for the location of any drawing which is generally familiar to most readers as its simplicity and general convenience have recommended it to all in need of a simple index system. One of the individual cards and the general index card covering that class is given herewith, which also gives an idea of the variety and extent of work done by the firm.

The practice is being followed of photographing all tracings and taking blue prints 7″ x 4½″ from the negatives, which gives a very convenient means of showing a prospective customer the salient features of a machine without going to the expense of sending him a full sized blueprint. These small prints are also very convenient in the shop for the use of the foreman, who can thus readily refer to all the drawings of a class at any time without the trouble that attends the use of the full sized sheets. One of these small prints has been reproduced full size in Fig. 9, which shows that in this shape the eye can perceive the idea and general construction of a machine easier than in a large drawing.

square feet. There is one smoke-pipe, 4 feet 4 inches in diameter, at a height of 42 feet 2 inches above the grates. Total weight of boilers, 47 tons.

There are five heavy box keelsons, which run the whole length of the vessel. The distance from centre to centre of frames is 24 inches; frames of T iron, 4½ inches by 4 inches; with reserve bars 4 inches by 2½ inches; keel plates, ⅝ inch thick; bottom and bilge plates, ⅜ inch thick; side plating and run aft, 5-16 inch thick; stem and stern posts, 6½ inches by 1½ inches; shear strake and plating carried up to the rail, ⅜ inch thick; deck beams are of T iron.

This vessel has been in continuous service to the present time over fifty-five years, and is apparently as good for service as ever. During all these years of service no signs of weakness were exhibited.

Her armament at the present time consists of six 6-pounders, two 10-pounder rapid-fire guns, and two machine guns. Of late years her principal occupation has been in the instruction of the United States naval militia at the different lake ports, and surveying.

LETTERS UPON PRACTICAL SUBJECTS.

ABOUT SHAPER SLIDES AGAIN.

Editor MACHINERY:

It was with considerable surprise that I read in the September issue of MACHINERY Mr. T. B. C.'s recommendation for the adjustment of the gibs of shaper slides. It would seem that this time-honored method of adjustment had sufficiently proved its inferiority as a reliable and durable device, although so extensively used as to be regarded by many as standard practice. It is unnecessary for me to point out its faults as they are only too well known to every machinist; and while T. B. C.'s method might be superior to that generally pursued, as it gives a more uniform adjustment, it is open to the same objections that render the ordinary form a non-reliable adjusting device.

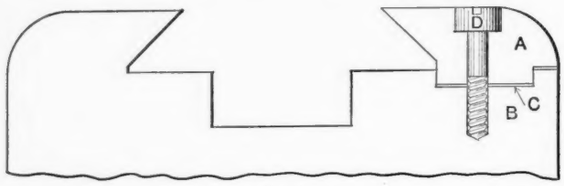


Fig. 1

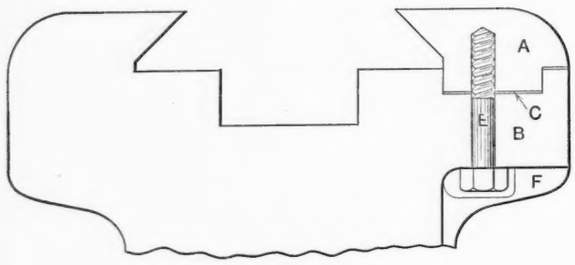


Fig. 2

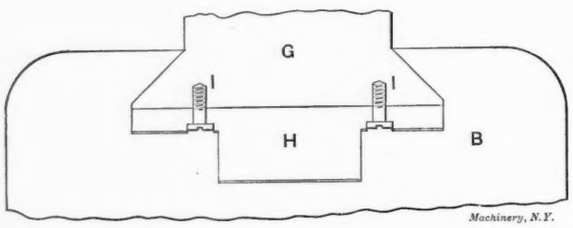


Fig. 3

While I am not a machine designer, it seems that the method shown in Fig 1 would be preferable for a shaper ram having V slides, as it is strong, gives uniform bearing and has the feature of being easily adjusted, which, however, the writer thinks is an objection. If a shaper is properly proportioned and built, there should be no reason for the continual tightening and loosening of the slides which is so much practiced. To overcome this objection the same method in its essential features for taking the slack is shown in Fig. 2, with the difference that the fillister head screws D in Fig. 1 through A into B are replaced by the hexagon head screws E in Fig. 2. The piece A is supposed to be drawn down solidly by the screws in each case, preferably without liners, which may, however, be used as shown at C. The heads of the screws are covered in Fig. 2 by the shield F, which should be fastened by a sufficient number of screws to discourage tinkering with the adjustment, but which could be readily removed in case it was thought to be really necessary.

The scheme shown in Fig. 3 is, in the writer's estimation, the winner of the three designs, and although not new, the principle is being used to a limited extent only in machine construction. The idea is to make the shaper ram G with a liner H fastened by the fillister head screws I I to the bottom and to take up the slackness due to wear by inserting liners between G and H. It is needless to say that no adjustment would be made until it was needed and when made it would very likely be done under the supervision of the tool-maker.

The making of machinery with this or similar adjustments is slowly coming into favor both with the makers and users of tools as it is reliable and unchanging. The boring machines manufactured by the Newark Machine Tool Works have it in a modified form on the cross-slide to the carriage and it is so protected from the machinations of the operator that it is necessary to take the table apart before any change can be made. The object sought is obvious, being to prevent undue slackness or tightness in this vital part of the machine. If the operator is allowed to manipulate the adjustment, he will almost invariably set up the screws after chucking a piece of work with the consequent result that the table is slightly sprung out of true, thus giving an inaccurate product.

F. EMERSON.

* * *

ANOTHER NOVEL SHAPER DESIGN.

Editor MACHINERY:

I note in the August number of your paper that Mr. Emerson proposes to abolish the trouble incident to the upward spring of a shaper ram when near the extreme outward portion of its stroke by cutting off the slides of the ram near the head so that the moment of the cutting force of the tool will remain the same at every point of the stroke and cause a uniform deflection of the ram at all points of the stroke.

This idea is certainly a novel one and there can be no doubt but that it will accomplish what is intended. It has the serious objection, however, that the depth of the shaper column would have to be much greater with a tool of this design than with an ordinary shaper. This is shown clearly in Fig. 1, which is a reproduction of Mr. Emerson's sketch, with a few lines and figures added. In Mr. Emerson's design, in which the slides are cut off at A, it is necessary to make the top of the column of a depth, x, equal to the length, y, of the ram, in order to maintain an even bearing and uniform conditions throughout the stroke. With the ordinary shaper, however, the ram can overrun at the rear of the column by nearly one-third its length when at its extreme inward position and still have a good bearing, allowing the frame to be made of the proportions shown by the dotted line at a, and resulting in quite a saving in the cost and weight of the tool.

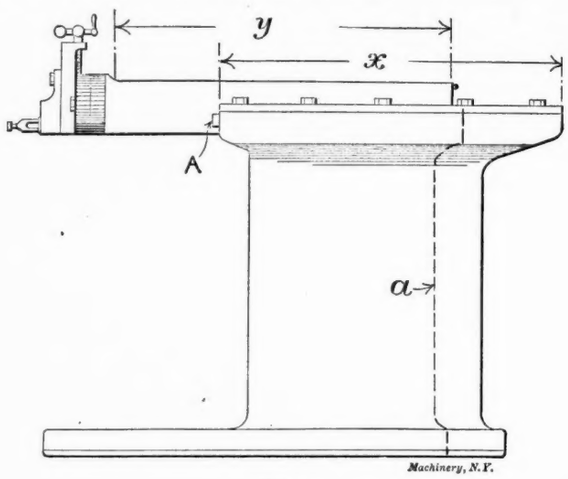


FIG. 1.

My suggestion is to adhere to the original design, so far as the arrangement of the slide on the ram is concerned, but to change the position of these slides from the bottom to the top of the ram, as shown in Fig. 2. In a shaper tool, as usually ground, there are two resultant forces to be overcome, as indicated by the arrows, one of which is in a horizontal direction, opposed to the movement of the ram, and the other is in an upward direction tending to spring the ram upward. The point A is the fulcrum or pivot about which these forces act and the upward thrust acts with a lever arm of length l, tending to move the outer end of the arm upward. With the arrangement of slides shown, however, the horizontal force acts with a lever arm h, tending to move the outer end of the arm downward.

With the arm fully extended the distance h would be less than the distance l, but this is compensated for by the fact that the horizontal force would always be greater than the upward force, making the moments of each balance nearly enough for practical purposes. Two driving gears should be used, one on each side of the central web of the ram and the driving racks should be on the under sides of the slides so as to bring the driving force and the slides as nearly as possible in a straight line.

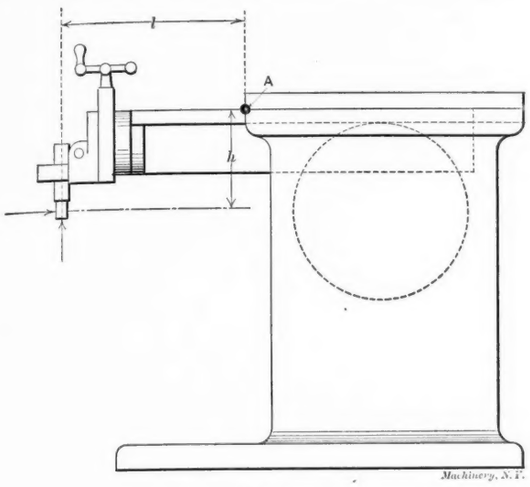


FIG. 2.

While Mr. Emerson's plan would accomplish the object sought, it is in the nature of a remedy rather than the removal of the cause. The spring of the ram would still be there, his remedy being simply to provide a means for making the spring uniform. By my plan the cause of the spring would be nearly or quite eliminated.

E. L. GRAY.

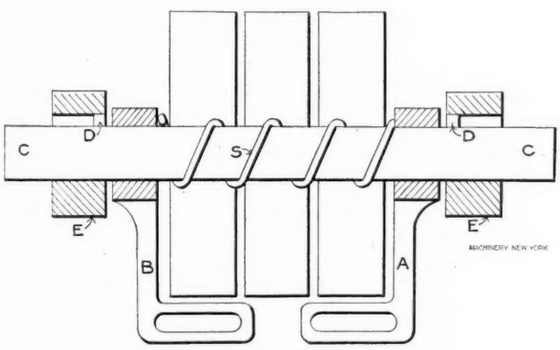
Westmore, Vt.

* * *

A NOVEL BELT SHIFTER.

Editor MACHINERY:

In a recent visit to Beaman & Smith's shop in Providence I saw a belt shifter that was about the neatest device I have seen in this line. It accomplishes all that the complicated shifters do, with their cams and toggles, only moves one belt at a time and doesn't take a double width tight pulley in the centre as some do, or as the plain shifting belt always does.



BELT SHIFTER.

The sketch isn't quite correct, as the belt fingers A and B are not made as shown, but this gives the idea without making another view. The hangers E E have a square hole through them and a keyway for the feathers D D to work in. The shaft or rod C C is square and carries the feathers D D referred to before. The fingers A and B are cored square and fit loosely on C C. The spring S also fits loosely over the square rod and between the fingers, tending to keep them apart on the rod. Calling A the forward motion and moving rod C (by handle or lever) toward the left, the feather D carries finger A and the forward belt along to the tight pulley in the center, driving the machine forward. When the rod is released the spring forces A back to its own pulley. If a reversal is wanted the rod C is moved to right and belt A forced off the tight pulley before belt B can go on, the feathers D passing through hangers in either direction, but always carrying one finger or the other towards the center. The spring S is not a tight fit between fingers, only enough to keep the belt from working on.

I call this one of the neatest schemes I know of, and, best of all, I am told it isn't patented. I am going to use it first chance I get and presume others will do the same.

FRANK C. HUDSON.

Tombstone, Arizona.

* * *

ABOUT THOSE EXAMPLES OF MANUAL TRAINING.

Editor MACHINERY:

In the August issue of MACHINERY I read with some interest and more apprehension the article entitled "Some Examples of Manual Training," by R. H. Smith of ———. Had I known his address I might have answered him directly, but it was not given, hence this letter. Another reason for making it public is that Mr. Smith gives the readers of MACHINERY a false impression of the manual training school graduate and appears to have an accurate impression himself which I wish to eradicate, if possible, without offense to any one. Being a practical mechanic, a pattern maker, a graduate mechanical engineer and an instructor of manual training and drawing I may without egotism assume to be competent to offer an explanation of the apparent failure of the apprentice.

It seems that Mr. Smith had an apprentice who was a graduate of a manual training school and who failed to solve some simple problems to Mr. Smith's satisfaction. He also has "observed a number of boys from different schools and in almost every case has noticed the same defect—an inadequate training or a woeful lack of confidence." This boy in the case cited, however, required only a few words to straighten out the difficulty in which he had become involved, and let us now examine the question from a metaphysical point of view. It is apparent that Mr. Smith was prejudiced against the boy and that his mind was in a negative condition concerning anything that the boy did. He was negatively inclined towards the boy's superior education and acted negatively either consciously or unconsciously towards him and thus influenced his mentality. The result was confusion and doubt in the boy's mind, a condition directly opposed to the best efforts on his part.

Thoughts are beginning to be recognized as forces and rightly so, as in this case the boy undoubtedly felt without understanding the negative condition of his superior officer's mind. By reason of prejudice that gentleman was looking for demerit instead of merit and imagines that it was found. He condemns on these isolated instances a system of education that in my mind is the salvation of the masses and a solution of the industrial problem since it puts reason and intelligence into labor. I would advise Mr. Smith when he has any more apprentices under his control to try and give them this faculty, he must give them a chance to prove their ability, as confidence is the child of experience.

Let us now consider some of the merits of the manual training school and its reason for existence. It does not attempt to teach a trade or profession, but is a school where the intellect is developed through the medium of things created. Manual training may and does direct the pupil to a proper selection of a trade or occupation. It teaches the principles and foundations of many trades and when the manual training student selects a trade, he does it intelligently, not because his parents choose it for him, but because he knows himself, a great knowledge, and he becomes a tradesman not a trades machine. Manual training schools bring forth the inventive faculties and nourish them; they educate the perceptions, the reason, the soul or mind.

A trade school, as its name implies, is a school where the pupil may be educated in some special branch of handicraft coupled with academic education, that will make him a skilled mechanic, a self-respecting citizen, an educated, therefore thinking man, not a trained automaton. To do this a broad education is necessary, morally as well as manually.

The shop man of to-day is a slave to ignorance and circumstances, perhaps narrower in some degree, than in the days of our fathers, because of the specializing of operations, the greed of the large shop owner and the creation of monopoly. What

is its cure? Education—a broad education of the masses, that will make the man a skilled mechanic, and an intelligent voter.

Space does not permit me to discuss this problem socially, ethically and industrially as I desire to, so I shall give some of the results of manual training and trades schools taken from the "Eighth Annual Report of the Commissioner of Labor, 1892." "Out of 3,030 trade school students, from countries throughout the world, statistics have been made as follows: 908 began work with their employers as apprentices, 2,079 as journeymen, the balance not reported. In 2,628 cases out of 3,030, the employers prefer trades school graduates to those who have not had trades school education.

"The following shows some economic results: Out of 3,030 student workmen 2,071 were found superior to ordinary workmen in the use of tools, while only 324 did not have such superiority. In economy of the use of materials 2,138 were superior to the ordinary workmen, while 636 were not. In planning and arranging work 2,684 were superior out of 3,030, while 307 were not superior to the ordinary workmen."

I offer these remarks in justice to an education which I foster and in justice to the boy that Mr. Smith *had*. Do these statements, made by government investigation prove the manual training education "inadequate" and "with a woeful lack of confidence?" I think not.

L. A. BUCHANAN.
Stockton, Cal. Director of Manual Training.

* * *

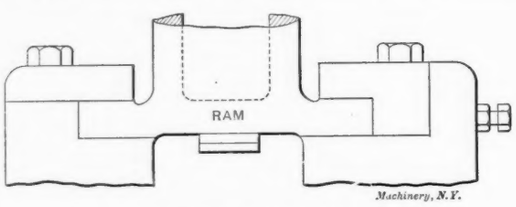
DOES NOT LIKE "FREAK" DESIGNS.

Editor MACHINERY:

I am inclined to doubt the need for any marked change in established practice in shaper design, as suggested by two or three of your contributors recently. I admit that many shapers will not plane parallel on full stroke, but I am quite sure that there are some of standard design, without any humps, special slides or other devices or attachments, that will plane accurately and true full stroke. On one of these, for example, I recently saw a set of machine shop parallels planed that were true within half a thousandth throughout their full length, by actual micrometer measurement.

If the shaper ram is made heavy enough, it will not spring appreciably; and if the fit in the slides is close enough and long enough, there will be no appreciable inaccuracy from that source. This fitting ought to be done so well that the shaper will run when the slide caps are bolted down rigidly. If it is necessary to slacken the screws as T. B. C. mentions, of course the machine will not do good work.

My suggestions for improvement, therefore, are to make the ram heavy, to scrape the slides to an accurate fit before the machine leaves the shop and to make the wearing surfaces of the slides so generous that they will seldom—I might almost say



PROPOSED SHAPER SLIDE.

never—need adjusting. These suggestions are along the lines of conservatism and good practice and I believe if acted upon will produce results superior to any of the more novel suggestions. It is at least certain that shapers built in this manner at the present time give good satisfaction.

Although the ram of a shaper is a moving part, there is not the objection to making it heavy that might be supposed. It should be remembered that while the kinetic energy of a moving body increases as the square of the velocity, it increases only directly as the weight, and a few pounds more placed where they will increase the stiffness will have very little effect on the power required to operate the tool. This is particularly true of crank shapers having a flywheel to alternately absorb and give out power at the end of each stroke. Beyond this, the added weight is an advantage, since it promotes steady action and eliminates chatter.

As far as the slides are concerned, a design like that shown in the accompanying sketch can hardly fail to give good results. There is nothing better than flat, square sliding surfaces. They are easy to construct, easy to adjust and keep in repair, and have less friction than angular surfaces. It always seemed to me, moreover, that thin steel gibs, set up with set screws, for taking up the wear, were about as poor an arrangement as could be devised. I much prefer heavy gibs like the one shown, which can be fastened rigidly in position. The thin gibs do not give an even bearing and it is impossible to adjust them uniformly from end to end.

OLIN SNOW.

* * *

IRREGULARLY SPACED REAMERS.

Editor MACHINERY:

I was considerably interested in the scheme presented by Mr. Hayes for the making of irregularly spaced reamers, although it was not altogether new to me, but one of our apprentices who is at present in the tool-room became badly confused in reading the description as published in the September MACHINERY and rather doubted that the edges of the teeth could all be made of the same thickness by the second indexing. While the description is plain enough to one familiar with tool-room practice, it is perhaps a little hazy to the average apprentice and I have ventured to send you the diagram and explanation which cleared up the difficulties for the apprentice mentioned.

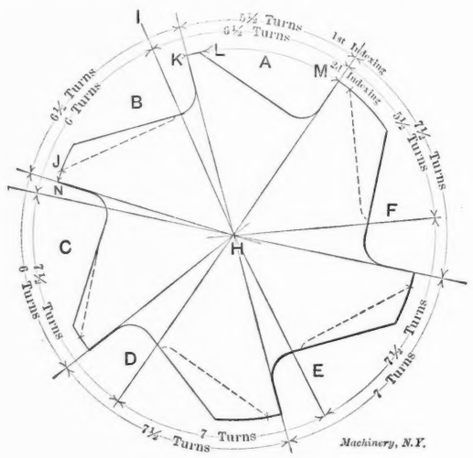


DIAGRAM OF REAMER.

Space A in the accompanying drawing is the first one cut and Hayes for the making of irregularly spaced reamers, although right for milling out the space B. The different indexings being followed through as suggested by Mr. Hayes brings us back to the original starting place at A, the various turns to the index crank being noted in the outside circle and those for the second indexing being given in the inner circle. As stated in the letter from Mr. Hayes, the first cut was started so that the width of land between the cut and the edge of the next tooth would be correct, so in the second indexing it will not be necessary to run the cutter through the space A but we skip one index and turn the crank 6½ times, which brings the cutter with the right edge, coinciding with the radial line I H, providing the reamer is cut so that the edges of the teeth are radial. The diagram is laid out with the distance K L equivalent in angular distance to one-half turn of the index crank thus making the width of the cut L, M equal to five turns of the crank. In space B, the original index was 6½ turns, but by indexing 6½ turns for space A one turn in the angular distance is cut off so that the width of the cutter, which is equal to 5 turns of the index crank would leave only one-half turn between J and N, and remove the stock along the dotted line. In the same manner the equality of all the other spaces can be shown which is always a very good thing to do when presented with a new scheme as it is always cheaper to experiment on paper than in the shop with cast iron or steel. This explanation made the scheme so clear to the apprentice that it is safe to say that if he is given a job of the kind to do, he will not need any of my assistance to get him started right.

By the way, it seems to me that if there was more matter of

an elementary nature published in the various mechanical journals, it would be a move in the right direction. There is a new crop of youngsters coming on the stage of action every year and they require education of the same elementary nature that was so acceptable to us ten or twenty years ago; but if the papers only publish that which will interest the older hands, the younger ones will have a rather dry time when reading up on their business. I would like to see more articles designed for the instruction of the apprentice and am willing to bet the price of a good hat that while the old heads may growl at it a little, they will read every word of it and get pointers, too. NEMO.

Providence, R. I.

* * *

ORDER NUMBERS AND TIME CARDS.

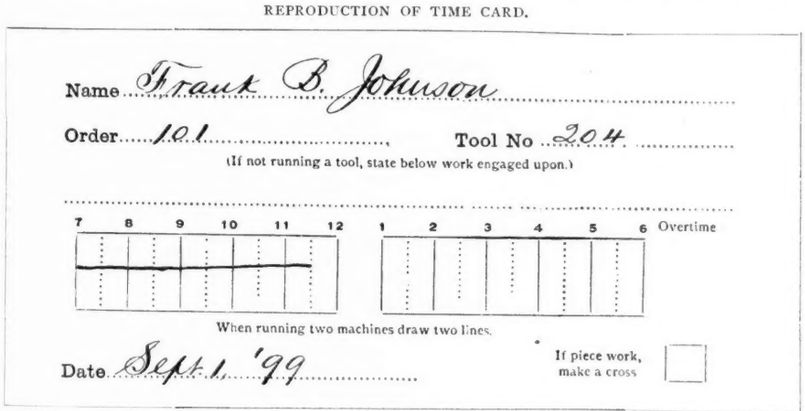
Editor MACHINERY:

The articles that you have published on shop management prompt me to offer a few suggestions about time keeping, principally with regard to issuing the order numbers for the different jobs and keeping the time cards. If a cost keeping system is to be of the greatest value, it should be so arranged that the cost of each operation on each piece can be obtained, if desired, and yet so flexible that it will not be necesssary to keep the cost in such detail if it is not desired.

The only way of getting the cost in detail, so far as I know, is to have the workman set down on his time cards the time taken for each operation, such as turning, boring, fitting, etc., and for convenience in filing I prefer to use a separate time card for each operation. If the time is not desired in detail, this can be arranged by the manner in which the order numbers are issued.

Suppose that a machine or a group of machines is to be built. The man who has them in charge should make out a complete list of all the parts of the machines, even to the screws and bolts, partly to facilitate ordering the castings and looking over the stock to make sure that there are no parts lacking, and partly to assist him in determining what parts he will wish to obtain the cost of after they are completed. If the machine is one that has been built regularly, it may be sufficient to obtain the cost of groups of pieces like those of the headstock or tail-stock of a lathe and all the parts of each of these groups would then be given the same order number. Or it might be sufficient to know the cost of the machine as a whole, or the lot of machines, in which case they would all go under one order number.

REPRODUCTION OF TIME CARD.


Name Frank B. Johnson
Order 101
Tool No 204
(If not running a tool, state below work engaged upon.)
7 8 9 10 11 12 1 2 3 4 5 6 Overtime
When running two machines draw two lines.
Date Sept 1 '99
If piece work, make a cross

On the other hand, if it were desired to know exactly what each part cost, or any particular part cost, as would be the case with a new machine, or if new jigs or improved methods were being tried, the part or parts should have separate order numbers. The idea is to depend upon the order numbers for the sub-division of the work instead of relying upon the workman to designate the various pieces that he has worked upon. This makes it necessary for the foreman, draftsman or whoever places the shop orders to give the matter a little conscientious study before the work is given out, which is a good thing.

In brief, all the work of the shop is done under order numbers. If the costs are wanted in detail, all the pieces are given separate order numbers. If the costs of groups of pieces only are wanted, then the groups are given order numbers and the returns will show the costs with greater or less detail according to whether a large or small number of order numbers were assigned.

The sample card below will show what part the workman plays in the system. We will suppose that he is working upon order 101, and is milling. He works from seven to half-past eleven at this, and the number of his milling machine is 204. He writes on the time card his name, the order number, 101, and the tool number, 204. He draws a line from 7 to 11:30, as indicated, to show the time and finally adds the date. It is much easier for a workman to draw a line indicating his time in this way than to have to figure up the number of hours worked. The tool number will indicate to the time clerk that his operation was milling, so that it is unnecessary for the workman to write the operation unless it is some such work as fitting, where there can be no tool number. If he is engaged on piece work he places a cross in the square at the lower right hand corner and if he is running two machines he draws two lines to indicate his time, instead of one. At 11:30 he is given another job or else starts on another operation on the same piece, and when that is finished he makes out another time card.

A convenient way of filing time cards is to have a row of small paste-board boxes in the office, such as are made by the Library Bureau, Boston. These boxes are of the right size to hold cards 3 by 5 inches, which is a convenient size. Each box should have an order number and the boxes be arranged with their order numbers coming consecutively. All the cards of one order number are placed in the box of that number and when a job bearing an order number is completed, the cards are removed from the box, and the box is given a new number. All the boxes back of this one are then moved up one and this box is placed at the foot of the line ready to receive time cards when its new number is issued.

Having each card represent one operation, it is possible to group the cards in the several boxes according to operations, the workmen's names, or the tool numbers, according to what information is wanted. Also, this information can be obtained very easily and quickly by any one.

With regard to numbering the tools in a shop it should be said that there is a decided objection to the usual method of doing this. Numbers are generally applied without regard to any particular system, new tools being numbered consecutively as fast as they are purchased. Unless one is familiar with the tools, it is difficult to remember what ones the different numbers designate; and even whether the numbers designate lathes, planers or what not. It would be a very simple matter to number lathes with numbers from, say, 1 to 500, milling machines from 500 to 600, planers from 600 to 700, grinders from 700 to 800, etc., reserving a sufficient number of numerals for future additions to each class of machines. Each class of machine would then come under its own numerical group and it could be told at once what kind of a machine any number designated. Then, as to which particular machine was meant, it could be judged somewhat by the numbers, because the newest machines would have the highest numbers. WILLIAM B. CHAPIN.

Boston, Mass.

* * *

A KINK FOR THE GRINDING MACHINE.

Editor MACHINERY:

Having been somewhat of a rover in the past, I have worked in the best as well as the poorest equipped shops in the country and have learned the valuable lesson that if up-to-date tools are not furnished, do the next best thing and use those which are at hand. The instance which I will recite occurred when I was employed in the gauge room of a shop that was at that time building bicycles. While all the tools were in the most wretched order it was the same old story of just as good work being expected from them as though they were up-to-date in every respect. I had not been in the shop long when the foreman came to me with a half-round broach 21½ inches long and ¾ inch in diameter with teeth ¼ inch in width and depth. The broach was cut with teeth the entire length, and the round part had been ground on a universal grinder in the grinding room, but the flat part could not be done there, which was

the reason for bringing it into the gauge room. As stated before, the job was given to me, and the foreman, with a wave of his hand, said: "You can do it on that grinder." The machine proved to be a surface grinder of modern design, but had received hard usage. I looked the machine over, but could discover no tools that were suitable for the job in hand. Being at the time a new man in the shop and having recommended myself as a first-class workman, I was naturally very anxious to hold the reputation, so I studied the situation for a few moments and decided on a plan which was thought would work satisfactorily. The table of the machine was carefully cleaned off and the broach laid on it in the position required for grinding. The foreman was then asked for some beeswax, but was informed that he had none, but that it could probably be obtained in the pattern department. Having secured the wax, it was put in a small ladle, and, having found a convenient gas-furnace, I was ready to begin operations. During this time I became aware that the foreman and the other machinists were closely watching me but I did not become "stage-struck" although the further the experiment proceeded, the more skeptical I became as to the final result. Having melted the wax it was poured on the grinder along each side and at the ends of the broach, the operation being continued while the wax hardened until the broach was molded in a bed of wax. It is needless to state that at this stage the room was well filled with smoke and that I was the center of curiosity. The emery wheel then received attention and was put in good order, by which time the wax was hard enough to commence grinding. No trouble was experienced in the grinding operation, and when completed the wax was easily removed. Upon calipering the broach with a micrometer it was found to measure the same throughout the entre length. The job was returned to the foreman and I must say that he exercised remarkable care in the examination of work if the scrutiny that the broach received can be taken as a sample of his inspection.

The writer remained in that shop for some months afterwards, and it is safe to say that beeswax could be found in every tool-chest, as no equipment was considered complete without it after receiving the little object lesson as to its possible use.

A. F. Horton.

* * *

HEARD FROM.

Editor Machinery:

In a recent issue of Machinery I noticed an inquiry from Mr. Hugh Hill, of Anderson, Ind., for the present location of a gentleman who called on him some years ago with a process for converting wrought iron and malleable iron into fine tool steel, together with a collection of samples showing the effectiveness of the process. I wish to state that I am the gentleman and that anyone who is interested in such a process, can communicate with me at the following address. W. J. Miles, Jr.

Middletown, Ohio.

* * *

ELECTRICAL PROTECTION OF SAFES.

In a paper read before the Chicago Electrical Association Mr. Clyde J. Coleman gave a description of the various means in use for the electrical protection of safes. He divided these systems into open and closed circuit systems, the former of which is but little used except in residences, where it has proved more of a nuisance. The commercial systems of electrical protection are all based on the closed circuit. Among the means mentioned for protecting premises are cementing narrow tinfoil strips on the inner surfaces of window glass so that any breakage or fracture of the glass will open the circuit; the use of glass tubes filled with mercury and connected in circuit, or tubes filled with water or compressed air, or the maintenance of a vacuum in a partition or enclosure, any disturbance from an abnormal condition resulting in an electric alarm being given. A good method is the use of wires kept under a definite state of tension by a spring, any increase or diminution of which will allow an arm to touch a contact point, thereby sounding an alarm. In reply to questions by members as to the use of electricity in perforating safes, it was stated that a five-ply chrome steel safe 3½ inches thick was pierced with a current of 120 amperes and 80 volts at the arc, in 20 minutes; with 175 amperes in 16 minutes, and with 300 amperes in 3 minutes. A five-ply safe of the same material 7½ inches thick was burned through by 300 amperes. A 3½-inch Corliss was burned through by 400 amperes in 1½ minutes.—"Electrical World."

TOGGLE-JOINTS.

AN EXPLANATION OF THEIR PRINCIPLES OF OPERATION.

Retsel.

The toggle-joint, while one of the simplest mechanisms to construct, is quite as difficult to understand as many of the more complicated movements. In Figs. 1 and 2 are shown the two simplest forms in which the toggle-point appears. In the first instance the force is supposed to be applied at F to overcome a pressure at P. In the second figure the right-hand arm is extended so as to form a handle to which the force is applied in a direction at right angles to the arm.

It should be noted that while this mechanism is called a "toggle-joint," it is really nothing more nor less than a crank and connecting-rod, of which the cross-head is at P and the connecting-rod from P to F, the right-hand arm corresponding to the crank.

The problem is generally to find how great a resistance at P will be overcome by a force applied at F; and as the resistance that can be overcome at P for a given applied force increases as the two arms approach a straight line, no calculation can be made until the positions of the arms are known.

Instantaneous Center.

All cases of the toggle-joint can be easily solved by what is known as the principle of instantaneous centers. This principle is simple and is clearly illustrated in Figs. 3 to 6, which apply to the two forms of toggle-joint shown in Figs. 1 and 2.

In any machine, simple or complex, no matter what its construction, the force applied, multiplied by the distance through which it acts, must equal the resistance overcome by the machine, multiplied by the distance through which it is moved. The principle of the instantaneous center affords us the means of finding the relative distances moved by the points where the force is applied and the resistance overcome.

In Fig. 3 ad and cd are the arms of the toggle-joint. What we call the instantaneous center is at o. It is located at the point where the perpendiculars to the lines along which the two ends of the arm ad move, this being the arm upon which forces F and P act. Thus, the end a moves in a horizontal line at right angles to line ao, and the end d, which is guided by the arm cd, and travels about the center c, moves for the instant at right angles to line do. The point of intersection, o, of lines ao and do is the instantaneous center.

The reason why this point is given the name of "instantaneous center" is because, if we consider the movements of the ends of the arm and the forces F and P for an instant, that is, for an infinitesimal time, they will be exactly the same as though the forces were rotating about the center o for that instant. To make this clearer, Fig. 4 has been drawn. This represents a bell-crank lever with arms eo and ao corresponding to the lines designated by these letters in Fig. 3. The axis, o, corresponds to the position of the instantaneous center of Fig. 3. Now it is plain, that if the lever be moved an exceedingly small distance about center o, the movements of points e and a will be precisely the same as the movements of forces F and P in the actual toggle-joint.

For example: Suppose it were found that for the position of the toggle-joint shown in Fig. 3 a downward push of .001 inch at d produced a movement at a of .002 inch. Also, suppose the lever in Fig. 4 to be constructed as directed, with the center-lines of its arms corresponding to eo and ao in Fig 3. It will then be the case that a downward movement of .001 inch at e will move point a .002 inch, just as in the toggle-joint.

Since the movements of the extremities of the two arms of a lever are proportional to the lengths of the arms, it makes the calculation of any toggle-joint very simple to first find the instantaneous center about which an equivalent lever may be assumed to turn, and then make the calculations as though based upon the lengths of these lever arms.

Illustrations.

Basing our calculations, now, upon the respective lengths of the lever arms, it ought to be clear from the reasoning given above, or even without that reasoning, that if the lever in Fig. 4 is in balance the force at e multiplied by the length of the arm eo will equal the force at a by the length of the arm ao. Returning to Fig. 3, this is equivalent to saying that $F \times eo = P$

× ao. To locate point o conveniently, erect at point a the perpendicular to the direction of force P, and continue cd until it intersects the perpendicular at o.

Transposing our formula, we now have

$$\text{Force } P = \frac{F \times eo}{ao}$$

When, as is often the case, the two arms of the toggle are of equal length, then eo will be equal to one-half ac, or ab and ao will equal twice bd. Substituting h for bd (in Fig. 1) and l for ab, we shall then have, for a toggle-joint with equal arms, like that in Fig. 1.

$$P = \frac{F \times l}{2 \times h}$$

Referring to Fig. 2, this case is best solved by first neglecting the handle F and assuming the toggle-joint to be composed of the linkage afc as in Fig. 5. Here the force f acts at right angles to the arm cd. It rotates about the center o with a radius fo and P rotates about o with a radius ao, as indicated in Fig. 6. Therefore, f × do= P × ao, Or,

$$\text{Force } P = \frac{f \times do}{ao}$$

With equal arms, do will equal dc = r in Fig. 2 and ao will equal 2 × h. Hence, for equal arms, as in Fig. 2,

$$P = \frac{f \times r}{2h}$$

Now, taking into account the increased leverage afforded by the handle, with the force acting at F, we have f × r = F × R. Or,

$$f = \frac{F \times R}{r}$$

Combining this with the equation above, the effect of force F upon P is found to be,

$$P = \frac{F \times R}{2h}$$

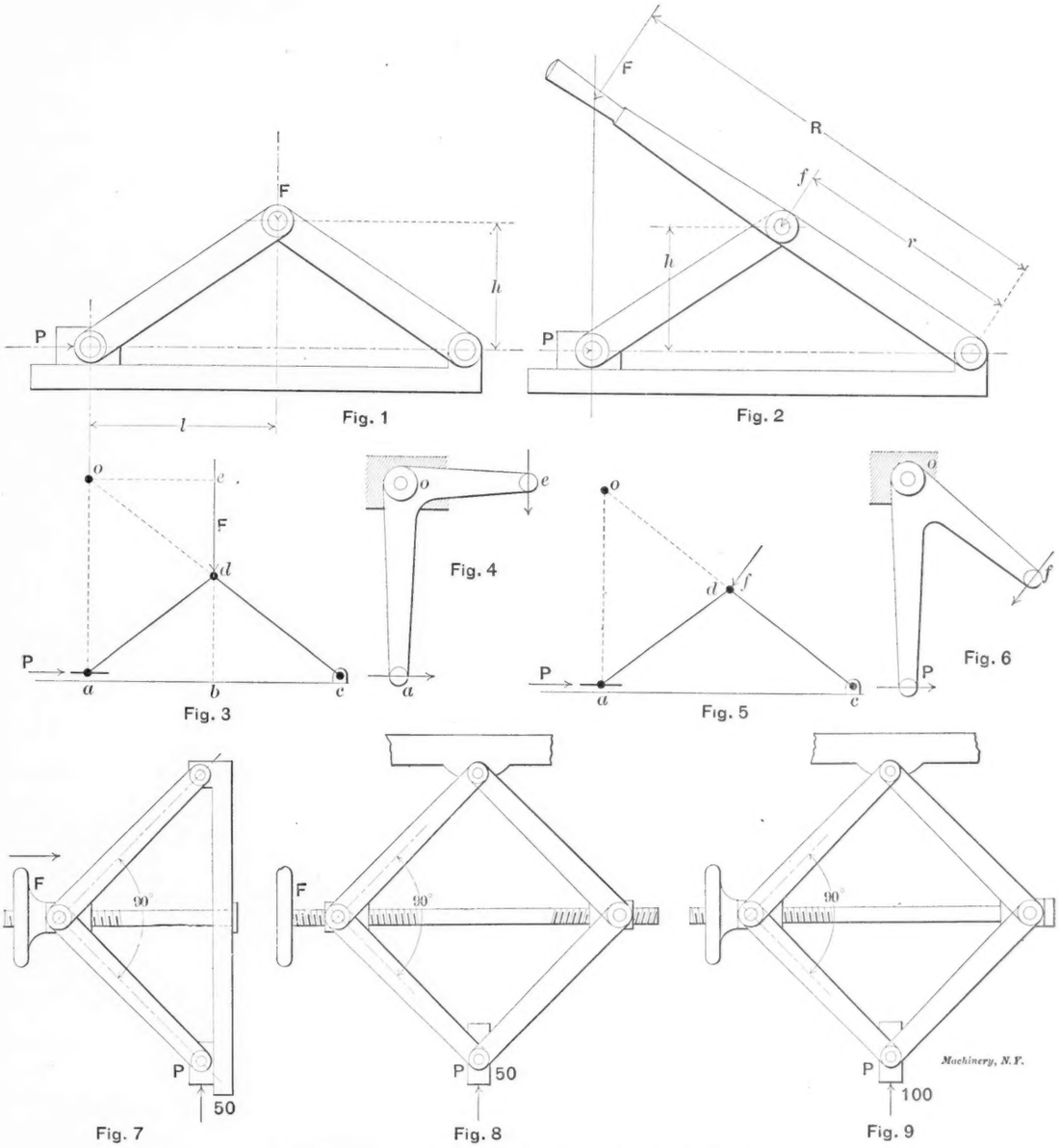


Fig. 1 Fig. 2 Fig. 3 Fig. 4 Fig. 5 Fig. 6 Fig. 7 Fig. 8 Fig. 9

DIAGRAM ILLUSTRATING THE ACTION OF TOGGLE-JOINTS.

Double Toggle-Joints.

In most presses in which a screw and toggle-joint are used, the latter is usually made in the form of a double toggle-joint, as shown in Figs. 8 and 9. The question is often asked whether such an arrangement is twice as powerful as a single joint, and to make this point clear let us first take up the joint and screw of Fig. 7.

Assume for illustration that the two arms are of equal length and at an angle of 90 degrees with each other and that a force F of 100 pounds is applied by means of the hand-wheel. With the proportions and position assumed, it is evident that a small movement of the joint at F will produce twice as much movement at P and consequently only half as much resistance, or 50 pounds can be overcome at P.

In Fig. 8 the same proportions and positions of the parts are used as in Fig. 7. While the action of these different joints can easily be demonstrated, whatever the proportions, it is simpler to take the positions shown, because the relative movements of the parts can be seen at a glance.

In Fig. 8 a right and left-hand screw is used of the same pitch as in Fig. 7 and one turn of the hand-wheel will therefore advance each one of the toggle-joints and also the point P just as far as the corresponding parts were advanced in Fig 7, and no farther. It will therefore take just the same pull on the hand-wheel to overcome 50 pounds at P as in Fig. 7, but as each joint takes half the strain, there will be only 50 pounds tension in the rod between the joints instead of 100 pounds as before.

In Fig. 9 the case is somewhat different. Here the rod is threaded at one end only, of the same pitch as before, and the hand-wheel screws on the threaded part, drawing the two parts of the joint together. One turn of the hand-wheel will advance the hand-wheel itself a distance, relative to the screw, equal to the pitch. Each side of the toggle-joint will be advanced a distance equal to half the pitch and point P will be moved twice this amount, or a distance equal to the pitch, or the same distance that the hand-wheel moves along the screw. Hence, if the hand-wheel produces a force of 100 pounds a resistance of 100 pounds can be overcome at P, or twice as much as in Fig. 7. The stress in the rod will, of course, be 100 pounds.

To summarize, one inch horizontal movement of the hand-wheel in Fig. 7 will produce two inches movement at P; one inch movement in Fig 8 will accomplish the same result and hence the resistance overcome will be the same; but one inch movement of the wheel in Fig. 9 will produce the same movement, or one inch at P, and this form of toggle-joint has twice the power, but half the motion of the other two.

* * *

THE "STRAIGHT EDGE" WAS CROOKED.

The "American Machinist" says in a recent issue that "A true story is told of a man who had a good stream of water running through his farm, and having heard of the wonders of a turbine water wheel, concluded to build him a mill. Having a nice level place by the creek, he built the mill. Finding out how much power he wanted and consulting the catalogue, he found that a certain size wheel at 22 feet head would do the business, and getting the guarantee that the wheel would work just as well under water as above, he proceeded to dig a well 22 feet deep, and put his wheel at the bottom of the well. It wasn't long after that he had a mill for sale and a water wheel to scrap.

An instance is known to the writer which, although not as absurd as that quoted above, still shows a degree of asininity scarcely credible. The owner of a small flouring mill had by economy and the labor of years accumulated quite a comfortable fortune and his business having increased to a degree that overcrowded the capacity of the old mill, he decided to build a new one on a site which promised greater advantages both for water-power and general location. Being of a somewhat parsimonious disposition, he begrudged the expense of hiring a surveyor to take the levels and give him the proper location of the dam and mill, so proceeded to do it himself. The site of the new dam having been chosen, the grade of the race and the height of the overshot wheel were determined by sighting along the edge of a sixteen-foot hemlock which had been located in a horizontal position by an ordinary carpenter's level at the low water mark of the dam. As it proved, however, the hemlock board was far from being an ideal straight-edge and after the mill was completed it was found that the top of the wheel was higher than the level of the dam. As the water persistently refused to flow uphill, the venture was a total failure and eventually ended in the financial ruin of the amateur engineer.

* * *

Most mechanics have their hobbies and a very common hobby among them is to devise a self-oiling loose pulley. There have been hundreds of different designs for them and it would doubtless be interesting to many if a few readers who have made successful loose pulleys were to send us descriptions of them for publication.

SHOP KINKS.

A DEPARTMENT OF PRACTICAL IDEAS FOR THE SHOP.

Contributions of kinks, devices and methods of doing work are solicited for this column. Write on one side of the paper only and send sketches when necessary.

A RIG FOR CUTTING LONG RACKS ON THE MILLING MACHINE.

Our contributor "G" sends a sketch and description of a rig that was recently used in his shop for cutting ratchet teeth in some long steel strips. The strips being of such length that it was necessary for them to project by the column of the machine, the rig shown in Fig. 1 was made for the job. The part D is of circular section and has a slot cut out as shown for the train of four brass gears E E E E, which transmit the motion from the main spindle to the supplementary spindle on which the cutter H is mounted. The bracket C, which is bolted to the table,

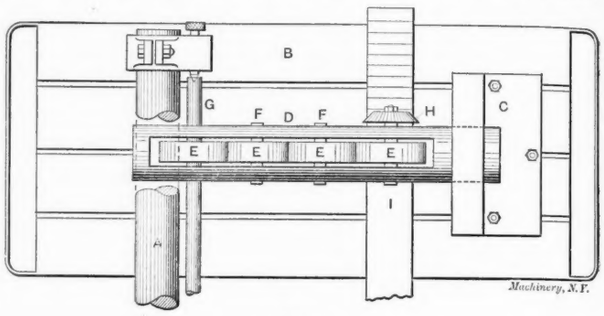


FIG. 1.

has a babbitted hole through the upper part for the passage of D. The part D fits freely in the babbitted hole, which is necessary for the movement of the table when feeding across the strip I. With this simple rig the teeth were cut without trouble by alternately cutting as many as the transverse movement would allow and then shifting the strip across the table a distance equal to its transverse movement.

Another scheme that may be of interest was that used in the repair of a cast iron gear several inches in diameter which had a number of teeth stripped off. The repair being a rush job, it was decided that it would be quicker to fix it in the following manner. The gear was mounted on a mandrel and turned off to about one-half an inch below the roots of the teeth. A ring bearing gear teeth was cast of brass and bored out to a perfect fit on the old gear which had been turned down. The brass gear ring B, Fig. 2, was pressed on A and then holes C C, etc., were drilled one-half in each part, which were tapped out. Screws were put in and cut off flush with the face of the gear which thus prevented the ring from working off. Although made in a hurry, the repaired gear is running yet and doing good work.

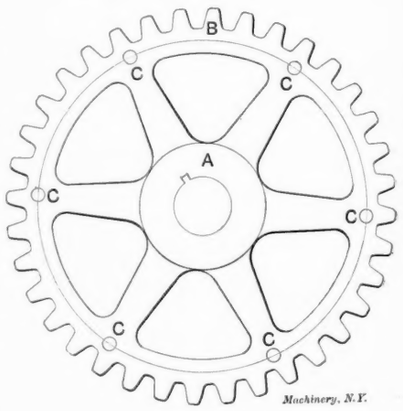


FIG. 2.

A SCRATCH GAUGE WITH MICROMETER ADJUSTMENT.

The simple form of scratch gauge having a fine adjustment is given to us by "J. E. S.," of Harrisburg, Pa., who claims it as his own design. From the sketch, Fig 3, and the description, we think that it may be a good design and one worthy of attention. The bar A is graduated from the end bearing the marking point F, which is rather peculiarly constructed, being a piece of square steel about 3-32 of an inch thick and sharpened from one side chisel fashion. The slot in which it is held is milled across the end, a hole having been drilled and tapped previously for the screw C, which being of larger diameter than the width of the slot, has enough thread to hold the marking point

securely. The graduation starts from the bottom of the slot so that when the marking point is ground correctly, no allowance need be made as the distance between it and the first graduation will be zero. The sleeve B is threaded for the part E and has two slots sawed in for about 1 inch, thus forming the tongue C in which the set screw D is threaded. To use the tool, the sleeve B with the knurled part E is shoved up to the approximate position and then the screw D is turned slightly to secure B to A. The effect of the screw is to lift the tongue D with its threaded end into the threads of E and to thus produce some

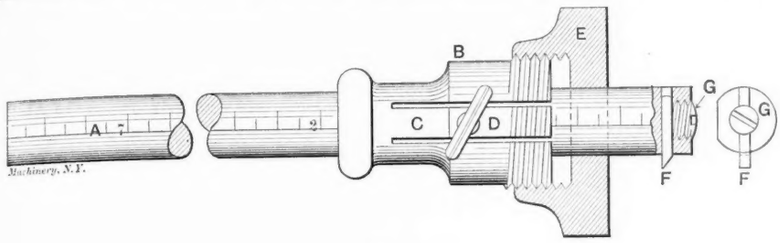


FIG. 3.

friction but not enough to prevent its turning for the final adjustment which is effected by turning E until its outer edge just coincides with the graduation desired. A final turn of the set-screw locks the two parts together when the tool is ready for use. The thread on B may be cut 25 to the inch and with 20 radial lines on the right face of E together with a longitudinal line on A, adjustments may be increased or diminished by five-hundredths of an inch or thousandths may be estimated.

CHISEL FOR CHIPPING STEEL.

A New York machinist says that a cape or round-nose chisel ground as shown in Fig. 4 forms a useful tool for removing tough hard steel as it will not break and has not much tendency to gouge in or to jump out. He found it useful on steel shafts which were to have a number of feathers sunk to a depth of 5-16 inches, the feathers being about 4 inches long and 1 inch wide. The keyways for the feathers were laid out and then four 1-inch holes were drilled with a flat end drill to the required depth. An attempt was made to cut out the metal between the holes drilled but the steel was nearly as hard and tough as the chisels, which made the chipping very difficult and discouraging.

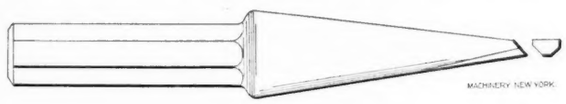


FIG. 4.

After a number of chisels had been spoiled, the scheme of grinding one as shown in the sketch was tried and found to work very successfully. Of course it could only be used as a stock-remover and not for finishing the key-ways, but as the principal breakages occurred when taking out the thick part of the intervening walls, this tool saved the finishing chisels.

He says that the same form of chisel has proved of value in removing a heavy section of wrought iron when necessary to surface off by hand a portion of a rough forging. On the latter work cross cuts are driven to a uniform depth of about 1/8 and 3/8 inch apart, which leaves the surface in excellent condition for finishing with the flat chisel.

* * *

WE WERE MISTAKEN.

Our attention has been called to an erroneous answer in the August issue of MACHINERY to Question 105, How and Why Department, by Mr. Porter Stafford, of Erie, Pa. The answer as given states that the crank of a bicycle should be constructed so that the pedal having the right-hand thread would screw into the left crank, and the one having the left-hand thread would go into the right crank. The reason for the answer was based on an examination of a bicycle which in the light of further investigation appears to have been wrongly constructed, and on the superficial theory that the backward tendency of the pedal would tend to continually tighten the pedal pins in the cranks when threaded as prescribed. The practice of the best makers, however, is exactly to the opposite, the right pedal having a right-hand thread and vice-versa. It is under these conditions only that the pedal pins tend to tighten in the cranks when under the influence of the rider. The reason for this apparently contradictory action is the slight epiclyclic movement that takes place between the threads of the pedal pin and those of the crank, being caused by what is known as the "wabbling action." The epicyclic movement may be easily demonstrated by taking a bolt having a loosely threaded nut, which is secured in a vise. Now give the end of the bolt a rotating action without actually turning it, and if the bolt be loosely grasped by the fingers, it will turn slowly in a direction opposite to the motion of the hand. So if the bolt has a right-hand thread and the motion given be in the direction of the hands of a watch, the resultant motion will slowly unscrew it from the nut.

. In the bicycle crank, the same action takes place even if the thread be a close fit, for the action of the rider's foot tends to give the pedal pin a wabbling action which, though very minute, still by reason of the epicyclic movement tends to turn it forward as regards the crank and the whole machine. If then, the left crank and pedal pin have left-hand threads, the pin will always tend to tighten in the crank, and consequently the right crank with its pin should have right-hand threads.

* * *

NICKEL STEEL TUBES.

In connection with the article in this number upon the Bethlehem Steel Co., who make a specialty of heavy forgings of nickel steel, a paper read before the Institution of Naval Architects by A. F. Yarrow will prove of value. The paper reported experiments made to determine the relative durability of boiler tubes of mild steel and nickel steel, the mild steel tubes being such as have hitherto generally been used in water tube boilers and the nickel steel tubes containing from 20 to 25 per cent. of nickel. The paper is summarized in "The Engineering Magazine," from which we quote.

The causes of the deterioration of boiler tubes are given as (1) action of acids in the water, due to the presence of grease, (2) oxidation on the outside by the action of the furnace gases, and (3) deterioration on the inside by the action of superheated steam.

Mr. Yarrow endeavored to repeat as nearly as possible the conditions which exist in actual practice, and by exposing both kinds of tubes to the same influence, to determine the relative resisting power of each.

The corrosion test was made by suspending weighed pieces of each kind of tubing in dilute hydrochloric acid for periods varying from 21 to 168 hours, the extent of the corrosion being determined by the loss of weight in each case. This test showed a remarkable advantage in favor of the nickel steel, the loss by corrosion of the mild steel tube being 16½ times what it was in the nickel-steel tube. Mr. Yarrow remarks that it may be contended that the relative corrosion of the two specimens when using dilute hydrochloric acid does not correspond with what it would be with such acids as are present in boilers under working conditions, but says, that it is not unreasonable to suppose that it may serve as a guide.

The second test was intended to show the action of gases and fire upon the exterior of the tubes. In this experiment two tubes were placed in a small brick furnace arranged so that they would be heated under identically the same conditions. The extent of the corrosion by the action of the heat and gases was determined by the loss in weight after repeated heating and cooling, the scale being removed between each heating, and the tubes weighed to ascertain the rate of loss. After five such heatings, coolings, and scrapings the nickel steel tube was found to have lost about 27 per cent. of its weight, and the mild steel tube 76 per cent., thus showing that the nickel steel resisted fire corrosion 2.9 times better than the mild steel.

The test with superheated steam was also in favor of the nickel steel, tubes of this material lasting 2 1-3 times as long as when of mild steel.

* * *

Most emery-wheel companies advise running their wheels at about 5,500 feet a minute.

FLY-WHEEL DESIGNING.

PRACTICAL SUGGESTIONS FOR THE DESIGNER, WITH AN EXPLANATION OF THE NECESSARY CALCULATIONS.

C. H. BENJAMIN.

In writing on this subject I shall begin at the beginning and not assume that the reader knows all about fly-wheels. Any reader who finds he is going over old ground may just stop and rest until the procession catches up with him. The object of all fly-wheels is to equalize the energy exerted and the work done and thereby prevent great changes of speed.

By energy exerted I mean the energy or power at the beginning of the machine, as at the cylinder of the engine or the driving belt of the shear press. By work done I mean the work at the end of the machine, as the belt wheel of the engine or the jaws of the press. If at any time the energy given to the machine is greater than the work which it is doing, then will the machine go faster and faster. So if at any time the energy exerted is less than the work being done, the machine will continue to lose speed.

In a shear press or punch the energy of the driving belt remains practically constant, but the work done by the jaws varies from practically nothing at return stroke to the full power of the machine when cutting. In an engine, on the other hand, the work done by the belt wheel may be constant, or nearly so, while the energy exerted by the steam on the piston varies throughout each stroke. Furthermore, in any engine using a connecting rod and crank, the energy exerted on the crank pin, tending to turn the shaft, varies from nothing at the end of the stroke to its greatest value near mid-stroke. A steam engine without a fly-wheel would be useless and could not make one revolution.

Now in what way can a fly-wheel help to overcome this difficulty? If such a wheel of large diameter and with a heavy rim were mounted on ball bearings to reduce the friction, it would even then be found difficult to set it in motion or increase its speed suddenly, on account of its inertia. To give to it any particular increase of speed would require a certain amount of work or energy put into it. Having once acquired speed it would be capable of doing the same amount of work on any opposing body by virtue of this stored energy.

So the fly-wheel of the engine or press, as long as the energy exerted is greater than the work being done, will turn faster, the inertia of its rim absorbing excess of energy. On the other hand, if the energy becomes less than the work, the wheel turns slower and slower, giving up its stored energy to supply the deficiency. The heavier the rim, and the greater its velocity, the less the change of speed for a given storage of energy.

In the steam engine these changes of speed occur twice in every revolution, the wheel moving most slowly near one-quarter stroke and most rapidly near three-quarters stroke, the exact times being dependent on the point of cut-off and the connecting-rod ratio. The use of the fly-wheel is often confused with that of the governor. The fly-wheel can only average the speed during one revolution and prevent violent changes in that time. It has no control over the number of revolutions per minute.

On the other hand, no ordinary governor works quickly enough to regulate the speed in one revolution.

The governor prevents any permanent change in speed by adapting the amount of steam admitted to the amount of work to be done. A governor will prevent an engine from running away; a fly-wheel cannot.

Weight of Rim.

In order to determine the weight of rim of a fly-wheel, it is necessary to know the probable excess and deficiency of energy in each stroke and the per cent, of variation in speed that can be tolerated. The earlier the cut-off of the engine the greater the variation in energy and the larger the fly-wheel that will be required. The weight of the reciprocating parts and the length of the connecting-rod also affect the variation.

In a subsequent article I will show how this may be determined graphically for any engine. At present it will suffice to assume it. The following table from Rankine's Steam Engine shows about what may be expected.

TABLE I. CONDENSING ENGINES.

Fraction of stroke at which steam is cut off	1/2	1/4	1/5	1/6	1/7	1/8
Per cent of energy	.163	.173	.178	.184	.189	.191

NON-CONDENSING ENGINES.

Steam cut off at	1/2	1/3	1/4	1/5
Per cent. of energy	.160	.186	.209	.232

To obtain the excess of energy from this table it is only necessary to find the average work in foot-pounds done by the engine in one revolution and multiply this by the decimal given in the table. We will call this excess of energy E.

The allowable variation in speed depends upon the use to which the engine may be put. In modern engines an allowance of from 1 to 2 per cent. is usual.

The limits of this article prevent me from developing at length the common formula for weight of rim. Since an explanation of this formula may be found in nearly any work on the steam engine it is hardly necessary to reproduce it here.

I will give a convenient form and illustrate its use by an example:

Let W be weight of rim in pounds.

Let D be mean diameter of rim in feet.

Let N be number of revolutions per minute.

Let $\frac{1}{n}$ be allowable variation in speed (from 1-50 to 1-100).

Let E be excess and deficiency of energy in foot pounds.

Let c be factor from table.

Let HP be indicated horse-power.

Then if the indicated horse-power is given:

$$W = \frac{387587500 \times c\,n \times H\,P.}{D^2\,N^3} \quad \ldots\ldots\ldots\ldots (1)$$

If the work in foot pounds is given, then:

$$W = \frac{11745\,n\,E}{D^2\,N^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

E is calculated as before explained. From these formulas it will be seen that increasing the diameter or the speed of a wheel diminishes the necessary weight of rim very rapidly.

To make clear the use of these formulas, we will work two examples, such as might arise in practice.

Ex. 1. A non-condensing engine of 150 indicated horse-power makes 200 revolutions per minute, with a variation of 2 per cent. The average cut-off is at one-quarter stroke and the fly-wheel is to have a mean diameter of 6 feet. Required the necessary weight of rim in pounds.

From the table we find c = .209, and from the data given we evidently have:

HP. = 150; N = 200; $\frac{1}{n}$ = 1-50 or n = 50; D = 6. Substituting these values in equation (I) we have:

$$W = \frac{387587500 \times .209 \times 50 \times 150}{36 \times 200 \times 200 \times 200}$$

or W = 2110 pounds nearly.

Ex. 2. A condensing engine, 24×42 inches, cuts off at one-third stroke and has a mean effective pressure of 50 pounds per square inch. The fly-wheel is to be 18 feet in mean diameter and make 75 revolutions per minute with a variation of 1 per cent.

Required weight of rim.

The work done on the piston in one revolution is, therefore: pressure on the piston multiplied by the distance traveled or twice the stroke in feet. The area of the piston in this case is 452.4 sq. ins., and twice the stroke is 7 feet.

The work done on the piston in one revolution is, therefore: 452.4×50×7 = 158,340 foot pounds.

From the table c = .163, and therefore:

E = 158,340 × .163 = 25,810 foot pounds.

From the data given we have: n= 100; D = 18; N = 75. Substituting these values in equation (2):

$$W = \frac{11745 \times 100 \times 25810}{18 \times 18 \times 75 \times 75} = 16640 \text{ pounds nearly}$$

Dimensions of Rim.

In the above formulas D, the mean diameter of rim, is really twice the co-called radius of gyration and would be found by squaring outer and inner diameters, adding them together, dividing by two and extracting the square root. In symbols this would read:

$$D = \sqrt{\frac{D_1^2 + D_2^2}{2}}$$

It is usually accurate enough to take $D = \frac{D_1 + D_2}{2}$, or the arithmetical mean

To illustrate we will assume $D_1 = 8$, $D_2 = 9$, then:

$$D = \sqrt{\frac{64 + 81}{2}} = 8.514$$

But the mean of 8 and 9 is 8.5, which is accurate enough in practice.

The number of cubic feet in the rim may be found by dividing the weight in pounds by 450 for cast iron or 480 for steel.

For instance, the rim in Ex. 1 would contain:

$\frac{2110}{450} = 4.69$ cu. ft. of cast iron,

and the one in Ex. 2 would contain: $\frac{16640}{450} = 36.98$ cu. ft.

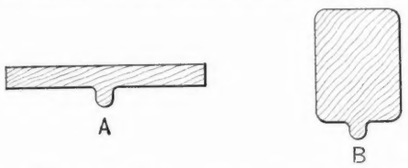
The area of cross section of rim may be found approximately by dividing the cubic contents by the circumference corresponding to the mean in diameter D. This area in Ex. 1 would be:

$$\frac{4\ 69}{6 \times 3\ 1416} = .2487 \text{ sq. ft.} = 35.83 \text{ sq. ins.}$$

and in Example 2:

$$\frac{36.98}{18 \times 3.1416} = .654 \text{ sq. ft.} = 94.2 \text{ sq. ins.}$$

The shape of the cross-section is determined by the use to be made of the wheel. If it is a belt wheel the width of rim is determined by the width of belt, and the section is usually something like A, below. If the wheel is to be simply a fly-wheel, it



is better to adopt a stronger form of section and one easier to fasten at the joints. A common form in such cases is like B. In very large wheels it is better to make the rim and arm hollow, as it is easier to cast and easier to put together. To illustrate the above principles, we will assume that the wheel in Ex. 1 is to carry a double leather belt sufficiently wide to transmit the desired horse-power. As this is not a paper on belting, I will only say that under the given conditions a belt 18 inches wide would be sufficient.

We may then assume that the rim should be a little wider than this, or say 19 inches.

The thickness will then be:

$$t = \frac{35.83}{19} = 1.88\frac{7}{8} \text{ inches nearly.}$$

On the other hand, if we assume the wheel in Ex. 2 to be used solely as a fly-wheel, we can take any proportions which may be convenient. If a width of eight inches is chosen, the depth will be:

$$\frac{94.2}{8} = 11\frac{3}{4} \text{ inches nearly.}$$

and the wheel will be about 19 feet in outside diameter.

If it is decided to make the rim hollow and a thickness of two

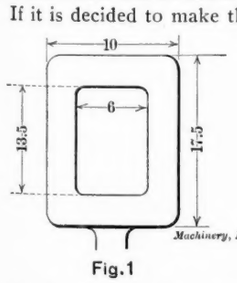


Fig.1

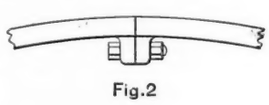


Fig.2

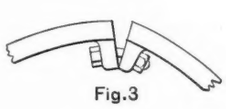


Fig.3

inches is adopted, the proportions would be about as in Fig. 1.

Joints in Rims.

Wheels less than 8 feet in diameter are usually cast solid. Wheels from 8 to 16 feet in diameter may be cast in halves to facilitate transportation. Wheels larger than 16 feet are usually cast in several pieces, the hub being a separate piece. Each arm may have a segment of the rim cast with it, but in the larger sizes of wheels the segments of the rim are bolted to the arms as well as to each other.

The bolts must be kept as snug to the rim and as far from the lower edge of flange as possible.

Until quite recently it has been customary to join the segments of the rims of belt pulleys by internal flanges and bolts, the joint coming midway between the arms. Theory and experiment both show this to be a very unsafe arrangement,* the strength of the joint being only from one-fifth to one-third that of the solid rim. When the wheel is running at a high speed, the pressure of the centrifugal force bends the joint out and opens it as shown in Fig. 3, thus throwing a great additional stress upon both bolts and flanges. If a joint like the above is

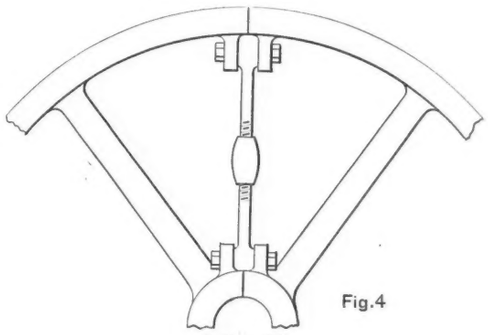


Fig.4

adopted, it should be strengthened by wrought iron or steel tension rods, running from the flanges to the hub, and preventing the rim from bending at the weak point. (See Fig. 4.) Mr. James Stanwood has suggested placing such a joint at a point one-quarter way from the arm, where the bending is practically nothing.

Most engine builders of late have put the joints in the rim directly over the arm. In any case, the bolts should be located as close to the rim as practicable.

Fig. 5 shows a joint in a belt wheel rim as made by a well-known firm of engine builders. This is a wheel 24 feet in diameter, with a 64 inch face intended for two belts. The flanges are well braced by the internal ribs and the bolts which hold the arms also assist in strengthening the rim joint.

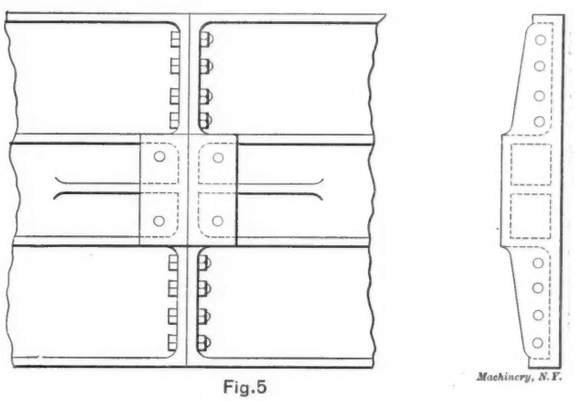


Fig.5

If a rim of this kind is very wide the centrifugal force tends to stretch the outer edges of the rim and to crack the cross flanges near the arms. In such cases it were better to use two sets of arms or two separate wheels.

A much safer and better rim, where it can be used, is the narrow and deep form. The tendency of bending between the arms due to centrifugal force is then resisted by the great depth of metal.

The links or bolts which form the joint can be placed nearer the center of the rim, where the bending will not affect them.

Two common forms of joints are shown in Figs. 6 and 7.

The links or prisoners, as they are sometimes called, are let in on the two opposite sides of the rim and occasionally on the inside face as well. They are usually put in hot and allowed to shrink into place, drawing the joint firmly together.

Experiments made at the Case School have shown that a joint

* See "Bursting of Small Cast Iron Fly-wheels," Trans. A. S. M. E., Vol. XX., p. 109.

of this kind may have a strength two-thirds that of the solid rim.

If the section of the rim is slightly increased where the link is inserted, the strength will be greater. (See Fig. 7.)

In a paper read before the American Society of Mechanical Engineers,* Mr. John Fritz has called particular attention to the advantages of the hollow rim and arms in fly-wheel construction. Fig. 8 is a sketch of a joint in such a wheel. The coring of the rim insures a sounder casting and also makes it possible to get a stronger joint, by thickening the metal at that point. The links are made of different lengths so that the heads will not all come at the same point.

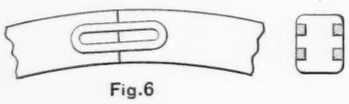


Fig.6

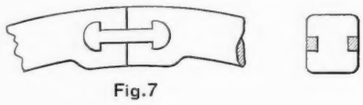


Fig.7

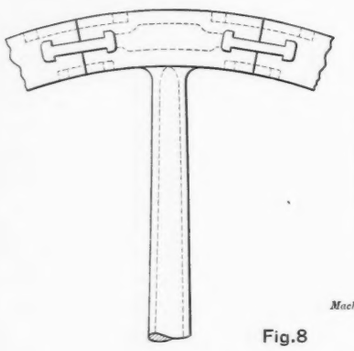


Fig.8

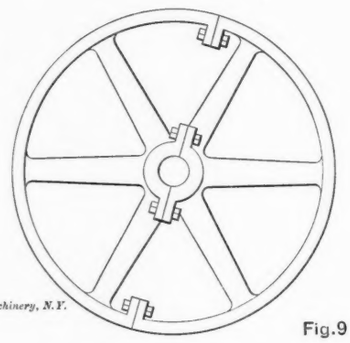


Fig.9

Size of Arms.

It is not possible to give any definite rule for determining the breadth and thickness of fly-wheel arms, there are so many disturbing factors. The thickness of the metal should be as uniform as possible, and where the arm joins the rim, if cast on, the change of thickness should be gradual, to avoid cooling strains.

Increasing the number of arms will strengthen the rim by diminishing the bending between the arms.

Under ordinary circumstances the stresses on the arm of a fly-wheel are slight, but when started or stopped suddenly, as in rolling-mill work, it is hard to calculate how large they may be.

†Experiments made on ordinary belt pulleys have shown that the bending due to belt tension is not evenly distributed among the arms, but is about twice as great on the arm which happens

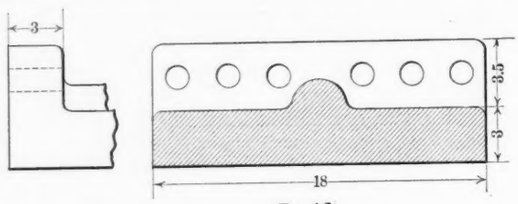


Fig.10

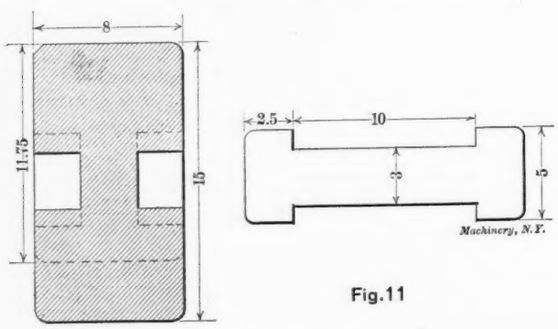


Fig.11

to be next the tight side of the belt at any instant. This difference is probably less in fly-wheels, on account of their stiffer rims, but even here I should prefer to design the arms for about twice the average moment.

* Transactions A. S. M. E., Vol. XX.

† American Machinist, Sept. 22, 1898.

Examples.

Ex. 3. It is required to design an internal flange joint for a fly-wheel rim 3 inches thick and 18 inches wide, the wheel being 10 feet in diameter and built in two halves.

A simple design in such a case is to part the wheel on a diameter which shall pass near two of the arms, as in Fig. 9. The distance from the joint to the center of the arm should not be more than one-quarter the space between the arms.

The flanges should be of approximately the same thickness as the rim. We will use steel bolts having a tensile strength of 75,000 pounds per square inch. If the metal in the rim has a tensile strength of 18,000 pounds per square inch the total tensile strength of the rim is $3 \times 18 \times 18{,}000 = 972{,}000$ pounds.

It will be found difficult to make the strength of joint more than one-third this, or 324,000 pounds.

$\frac{324000}{75000} = 4.325$ sq. ins. of bolt area required.

Six 1¼ inch bolts will have a combined area at the root of thread; $60 \times .89 = 5.34$ square inches.

With bolts even as large as this, the flange will probably break before the bolts. The joints would appear as in Fig. 10.

The bolts must be kept as snug to the rim and as far from the lower edge of flange as possible.

Ex. 4. Let it be required to design a link joint for the rim of the wheel in Ex. 2, supposing the rim to be solid, 8 inches wide and 11.75 inches deep.

Assuming the tensile strength of the cast iron as 18,000 pounds per square inch, the total strength of rim is:

$8 \times 11.75 \times 18{,}000 = 1{,}692{,}000$ pounds.

If the tensile strength of the steel used for links is taken as 75,000 pounds per square inch, and we try to make the joint two-thirds as strong as the rim, we shall need:

$$\frac{2}{3} \times \frac{1692000}{75000} = 15 \text{ sq. ins. of steel.}$$

If we adopt the form of joint shown in Fig. 7 and use two links, the area of cross-section of each link will be 7.5 square inches, or 2.5×3 inches. Fig. 11 shows the proportions of such a joint. As the heads of the links will remove $2 \times 2.5 \times 5$, or 25 square inches of metal from the cross-section of the rim, it will be necessary to add this amount by increasing the depth at the joint to about 15 inches.

* * *

In referring to the radiation from steam pipes in an article in a recent number of "The Engineering Magazine," R. S. Hale states that he believes too large pipes are used in a great majority of steam plants. While this opinion may appear heretical, it does not seem unreasonable with Mr. Hale's explanation added. He says, "the steam pipes close to the engine must be large, otherwise the pressure will fall during admission to the cylinder; but if a large steam pipe or steam reservoir be provided close to the engine, of sufficient size to keep up the prssure during the admission period, then (for an engine cutting off at one-quarter stroke) the steam pipe from the boiler to this reservoir need be of only one-quarter of the area or one-half the diameter usually used. The writer has often seen a 12-inch main with 6-inch offset pipes, leading to the engines, and wondered whether a 6-inch main with 12-inch offsets to the engines would not give a higher initial pressure on the indicator card."

* * *

An item in "Electricity" says that of late all sorts of impossible names have been suggested for a self-propelled vehicle in lieu of the word "automobile." A recent writer to a daily paper urges, apparently without any special reason, that the name "tomole" be adopted. The next thing will be that some one with a vivid imagination will suggest that an electrically propelled vehicle be called a "tamale" and a mineral spirit motor-driven carriage a "hot tamale," which latter designation—especially the first part of it—would seem very appropriate and almost as sensible as the name suggested by the correspondent referred to.

A SYSTEM OF PATTERN KEEPING.

G. H. Hall.

The advantage of having a complete record and a convenient arrangement of patterns is unquestionable, but the extent to which this recording and arranging may be carried must depend upon the circumstances governing the particular case. In the large works a pattern keeper and inspector is employed and the recording is systematized to a very fine point. In the smaller shops, however, when the amount of work is not sufficient to warrant a regular keeper, the patterns are usually picked out by a draftsman or superintendent and sent into the foundry, and when the work is completed are returned to the most convenient shelf by one of the moulders.

The next time this pattern is wanted, lucky is the draftsman if he finds it at all, and more so if some of the core boxes have not been misplaced or lost.

NAME OF MACHINE. 20" Lathe — PATTERN MARK. 20L

NAME OF PIECE	PATTERN NUMBER	NO. PER MACH.	MATERIAL	PATTERN MADE OF	NO. OF LOOSE PCS.	NO. OF CORE BXS.	NO. OF STOCK CORES	WEIGHT OF CASTING	REMARKS
Bed	1	1	CI	Wood	2	1	4	780	
Leg (Tail End)	2	1	CI	Wood	0	0	2	200	
Leg (Head End)	3	1	CI	Wood	3	0	2	220	20L 2 altered
Head Stock	4	1	CI	Wood	6	3	0	340	
" " Cap	5	2	CI	CI	0	0	0	58	
Spindle Box (Front)	6	1	Bz	CI	0	1	0	20	
" " (Back	7	1	Bz	CI	0	1	0	22	
Core	8	1	CI	Wood	2	1	1	85	

PATTERN SHEET.

The system of pattern keeping here described is applicable to such shops as this where the handling of the patterns may fall to anyone of several persons, the idea being to have the record so placed as to be convenient for any one to refer to, and the place for each pattern so marked as to offer no excuse for anyone to misplace it.

The record is the first part of the problem to be dealt with, and while some alterations may be necessary for different classes of work, we will consider the case of a shop manufacturing several sizes of lathes, shapers, drill presses, etc.

First, a letter is selected to represent each of the different tools. The first letter of the tool name is preferable unless two tools have the same initial letter when another letter may be chosen for one of them. Thus L would represent lathes; S, shapers; D, drill presses, etc.

Prefixed to this is the number indicating the size by which the machine, to which the pattern belongs is known, as 10 L for a pattern belonging to a lathe of 10 inch swing; 24 S for one belonging to a 24-inch stroke shaper. This combination of number and letter forms what is known as the pattern mark. Under this mark the patterns are arranged in serial, so far as possible, giving the same number to similar parts; that is, lathe beds would be, $\frac{10L}{1}$, $\frac{18L}{1}$, $\frac{24L}{1}$; headstocks, $\frac{10L}{4}$, $\frac{18L}{4}$, $\frac{24L}{4}$, etc. This, however, is applicable only to the principal parts, as it seldom happens that the different sizes are composed of exactly the same parts. The record is now made out as shown in the above sample, which is a copy of a pattern sheet for a 20-inch lathe.

These sheets should be printed in blank on bond or parchment paper from which prints can be made, and should be of the same size as a standard drawing sheet, so as to facilitate filing. The ones in use by the writer are 9 inch by 12 inch, which is the size of a standard one-eighth size drawing. This record is made out and kept in the drawing room and when the drawing of a piece is made, it is entered on the record by name, number, material, and number per machine. The number assigned to the pattern is put on the drawing and, by the pattern maker, is stamped on the finished pattern. When the pattern is completed, it should be examined by the draftsman and the record completed by filling in the number of loose pieces, core boxes, stock, cores, and any remarks which he may think neccessary. The column containing the weights of the castings will be found very useful in estimating or to use for reference in taking inventory of stock. The record on bond paper may be used by the office and drawing room in ordering castings, but it should never be allowed to go into the shop. For shop use blue prints are made and mounted on small boards as shown in Fig. 1. These are a little larger than the sheet and are provided at the top with a drilled hole by which they may be hung up. The name of the machine indexed is painted in black on a white strip at the top of the board, or a strip of paper bearing the name of the machine may be pasted on the board. The blue prints are stuck on these boards just below the title and the boards are hung upon the shelves where their respective patterns are placed. When only one or two additions are made to the original pattern list the changes can be made on the blue prints with yellow crayon; but blue prints are cheap and as soon as a number of changes are made, the old print should be removed and a new one put on.

But little can be said regarding the shelves on which the patterns are kept, as the space devoted to pattern storage is so varied, but when new shelves are erected, the arrangement shown in Fig. 2 will be found very convenient. Each machine is given a separate tier of shelves and the patterns are arranged as shown in the figure; the heavier ones occupying the floor space. The smaller ones are placed on the lower and more convenient shelves, while the higher and less available space furnishes a desirable place for keeping master patterns and patterns of jigs, fixtures, etc., which, although seldom used, are too valuable to be lost or misplaced. If the number of such patterns is very great they also should be indexed in a manner similar to the regular patterns.

The index board is hung in a conspicuous place as shown in the figure, and when a pattern is desired its place can immediately be found by these boards. The index shows just what kind of a pattern one is to look for, the number of core boxes and loose pieces and the number of stock cores to order.

The weight of the casting shows whether the pattern is large or small so that one knows at once whether to look on the floor or on the shelves for the pattern desired.

FIG. 1.

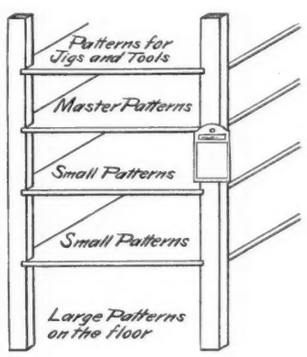


FIG. 2.

In returning the pattern, the index should again be consulted to make sure that all the loose pieces and core boxes are returned with the pattern.

The foregoing shows just how one set of patterns is being kept in a very satisfactory manner and by slight alterations that the different classes of work may require, it will be found a very convenient method of keeping any kind of patterns with but little trouble or attention.

* * *

Where are the largest machine tools located in this country? What are their dimensions and by whom were they made? These are questions that subscribers sometimes ask us, and that all mechanics would like to have answered. We will gladly welcome any information that readers are able to give us regarding tools of unusual proportions.

LIFE AND METHODS IN A GERMAN SHOP.

ROBERT GRIMSHAW.

At the principal repair-shops of the Royal Saxon Government Railways at Chemnitz, Saxony, there are at present employed over 1,500 men. One of the first things which strikes the visitor on entering the establishment is the restaurant. It may be laid down as a broad general principle that no German is going to be more than one-quarter mile from a restaurant, nor more than one-eighth mile from a Bier-Stube. The restaurant is a governmental affair, with plain tables and benches for 600 men at once, and has at one end large heating tables with sand-baths, on which the workmen who come from too great a distance to permit of going home for dinner (the shops are at the edge of town) can heat their coffee, etc., free of charge. Those who do not bring their eatables and drinkables with them can buy them of the government at a fixed published rate; sausages, sandwiches, etc., as well as coffee and beer, being obtainable.

For the accommodation of those workmen who live at too great a distance from the shops to permit of walking, the government runs special workmen's trains (on which the workmen ride free) at suitable times to bring them to the shops and take them away without making them too late or too early.

In the lower half of each window of the restaurant hall (which is also the pay-room) there is fitted a large board with several hundred numbered hooks, from which the workmen as they go through, take off, or on which they hang up their brass time-checks; the board being turned so as to face outwards at coming time and in the room at going time.

Accident and life insurance are compulsory. In each shop-building there is an "emergency closet," in charge of the employee at the nearest machine, and this contains all necessary bandages, plasters, ointments, and simple implements for treating cuts, burns, scalds, and bruises, and for removing bits of steel from the eye, as well as cholera-drops and a few other remedies likely to prove useful.

The heating devices are steam pipes under the work-benches which line the walls. The system of overhead steam-pipes which we find in some American shops, especially where there is a great number of vertical belts to establish a circulation of the heated air, is unknown in this country, and elicited very uncomplimentary remarks as to its practicability.

In paying off, each man receives his cash at the end of the week, in a tin "capsule," like a blacking-box, bearing his number; and this is enclosed in an envelope bearing or containing a detached statement of the amount paid, and the time or jobs for which it is paid. The workman verifies the amount and the details, and if there is any error or discrepancy, or he has any reason to be dissatisfied, he makes his complaint at once. On going out, he deposits his metal capsule (which, of course, has the same number as his time-check) in a general receptacle, from which it is taken to be used at the next pay-day.

These shops make their own leaf springs (spiral springs under cars are nearly unknown here). The spring-heating ovens are side-fired; the heating chamber being double-ended, and the firing chamber also, each having counterbalanced doors at each end. The flames pass over the springs, which lie on a flat iron hearth-plate, and then having thus traversed the oven crosswise, pass back again crosswise directly under the spring-hearth; next passing crosswise again in the first direction, at the bottom of the oven, and out to the flues which lead to the stack. There are square holes at each end of the ovens, closed with cast-iron plates, to permit of cleaning out these flues.

All tires are fastened on to the centers with dove-tail rings, having an opening into which is driven a key. This method of fastening has the disadvantage that at times the tires slip around a bit on the centers. It must be remembered that cast-iron centers for either locomotive or car wheels are here unknown; and many of the officials make me repeat my statement that "guss-eisen" (cast-iron) can be trusted and is the rule with us, for this purpose. They think that I get the name wrong for "fluss-eisen" (ingot-iron).

There is a great deal more anvil forging done here than with us; for instance, the buffer-guides are forged up as three- armed or four-armed spiders having a central hole, and then upset so as to make tripod-like guides, which are bolted to the buffer-beam and through which the stems of the buffers (two for each car) pass. Then there are the chains and hooks by which the cars are coupled, and numerous other parts which are either totally lacking on our cars, or are made with us of gray iron or malleable; or if of wrought-iron are drop-forged or hydraulic-squeezed.

I found that the shops were now making the 1½ inch crucible-steel anti-friction balls for turn-tables, by hand forging, at a cost of 60 pfennings (less than 15 cents), all finished smooth, as against 3 marks (about 71 cents), which they used to cost when turned up in the lathe.

On every engine tire there is a "limit line" turned:—a score which indicates the minimum thickness permissible. This seems to me in some respects better than a mileage limit. Tires are run to a certain thickness under fast express passenger trains and then degraded to "personen-zug," or ordinary passenger service, before being put into the freight traffic. (These "personen zuge" are usually called by the traveling public "bummel-zuge," or bummer trains; and the fare is always less on them than by the fast trains; or rather all tickets are good for the common trains, and if you travel by express train you must buy an "erganzungs billet," or "zuschlag billet" at about one-eighth extra.)

Here copper fire-boxes are used exclusively, and the stay-bolts are of copper, 1 inch thick in the cylindrical part, and 1¼ inch over the threads; being screwed in and then riveted over. Each bolt is drilled centrally nearly half way through from each end. On some other roads the drill-hole is nearly through from the inner end, and on some nearly through from the outer.

* * *

ENGINE EFFICIENCY.

To arrive at an idea as to the limits between which improvement in the present steam engine may be expected, let us take the case of an engine, such as that of a locomotive, working non-condensing and using, say, 3.5 pounds of coal per hp-hour. In the case of a locomotive, 50 per cent. would probably be a high efficiency for the boiler, thus allowing but 1¾ pounds of coal to be utilized in making steam. Assuming that the combustible matter in a pound of coal will give rise to 13,000 heat units, we will have 22,750 heat units from the given consumption of coal per hp-hour. Assuming a boiler pressure of 150 pounds and a back pressure of 4 pounds, the temperature range of working is 141 degrees; the absolute temperature of steam at 150 pounds pressure is 829 degrees, and since the ratio between these figures gives the heat available for transformation into work, in this case 17 per cent. of the heat units supplied to the steam or 3,867 heat units, are thus available. As a hp-hour contains 2,545 heat units, this gives with the above data for the given steam engine, considering it as a machine for turning heat into work within the limits set by the second law of thermodynamics, an efficiency of 65 per cent. Owing to the nature of heat losses, it cannot be expected that this efficiency may be very largely increased. Of course, by using higher pressures and the condenser, a greater economy may be obtained with the same type of steam engine, but little greater efficiency, as 70 per cent. is about the upper limit for the most improved modern types of engines. Yet 70 or even 65 per cent. scarcely justifies the opinion very widely held as to the inefficiency of the steam engine, and certainly bars claims for double or triple increase of efficiency, which claims do not seem impossible when the figures for thermal efficiency are considered as those upon which improvement is to be made. —ELECTRICAL WORLD.

* * *

It is said that to the province of Quebec belongs the credit of having built the first steamship that crossed the Atlantic from either side. The steamship was called the "Royal William," commanded by Captain McDougall, and sailed from Quebec on the 5th of August, 1833, arriving at Gravesend on September 11, having steamed the whole distance. This seems at first sight to contradict the well-known claims to priority made for the "Savannah" as the first steamship to cross the Atlantic. The "Savannah," however, on her memorable voyage from Savannah to Liverpool (May 26, 1819, to June 20, 1819) used her engines during 18 days and progressed under sail the remainder of the time, the paddlewheels being hoisted on board when not in use.

WHO INVENTED STEAM NAVIGATION?

POSSIBLY THE HONOR BELONGS TO A SPANIARD OF THE SIXTEENTH CENTURY, INSTEAD OF FULTON AN INTERESTING PRESENTATION OF THE EVIDENCE.

One of the most interesting and scholarly books ever written is that by Thomas Ewbank upon hydraulics and mechanics. The first edition appeared in 1841 and it has since run through at least fifteen editions. We presume the book is now out of print, but copies are to be found in many of the large libraries.

The book is largely historical and treats exhaustively upon various branches of the development of mechanics. In discussing steam navigation it states that in 1543 a naval officer is said to have propelled a ship of two hundred tons by steam in the harbor of Barcelona. No account of the machinery exists except that there was a large copper boiler and that there were paddle-wheels at the sides of the vessel. Like all old inventors this officer refused to explain his mechanism. The following account of the affair is said by Ewbank to be a copy of the official records contained in the Spanish Royal Archives:

From the Official Records.

"Blasco de Garay, a captain in the navy, proposed in 1543, to the Emperor and King, Charles the Fifth, a machine to propel large boats and ships, even in calm weather, without oars or sails. In spite of the impediments and opposition which this project met with, the emperor ordered a trial to be made of it in the port of Barcelona, which, in fact, took place on the 17th of the month of June. of the said year 1543. Garay would not explain the particulars of his discovery; it was evident, however, during the experiment, that it consisted in a large copper of boiling water, and in moving wheels attached to either side of the ship. The experiment was tried on a ship of 200 tons called the Trinity, which came from Colibre to discharge a cargo of corn at Barcelona, of which Peter de Scarza was captain. By order of Charles V., Don Henry de Toledo, the governor, Don Pedro de Cordova, the treasurer Ravago, and the vice-chancellor, and intendant of Catalonia, witnessed the experiment. In the report to the emperor and to the prince, this ingenious invention was generally approved, particularly on account of the promptness and facility with which the ship was made to go about. The treasurer Ravago, an enemy to the project, said that the vessel could be propelled two leagues in three hours—that the machine was complicated and expensive, and that there would be an exposure to danger in case the boiler should burst. The other commissioners affirmed that the vessel tacked with the same rapidity as a galley manoeuvred in the ordinary way, and went at least a league an hour. As soon as the experiment was made Garay took the whole machine with which he had furnished the vessel, leaving only the wooden part in the arsenal at Barcelona, and keeping all the rest for himself. In spite of Ravago's opposition, the invention was approved, and if the expedition in which Charles the Fifth was then engaged had not prevented, he would no doubt have encouraged it. Nevertheless, the emperor promoted the inventor one grade, made him a present of two hundred thousand maravedis, and ordered the expense to be paid out of the treasury, and granted him besides many other favors.

"This account is derived from the documents and original registers kept in the Royal Archives of Simuncas, among the commercial papers of Catalonia, and from those of the military and naval departments for the said year, 1543.

"Simuncas, August 27, 1825. "THOMAS GONZALES."

Comments on the Above.

Ewbank says that so long as the authenticity of this document be admitted it is difficult to perceive how other than Blasco de Garay can be accredited with the invention of steam navigation. It may appear singular that this specimen of mechanical ingenuity should have matured in Spain, but at that time this country was probably the most promising scene for the display of such operations. Every one knows that half a century before Columbus could find a patron nowhere else.

Objections have been raised to the claim for Garay and we give them as Ewbank presents them, together with his discussion regarding them. They make interesting reading and we leave the reader to judge as to their value.

"The objections are: 1st. Because the document was not printed in 1543; 2d. It does not sufficiently prove that steam was the motive agent; 3d. If Captain Garay really did employ a steam engine, it was according to all appearance the reacting eoliple of Hero, and therefore nothing new.

"To us there does not appear much force in these reasons. M. Arago observes: 'Manuscript documents cannot have any value with the public, because, generally, it has no means whatever of verifying the date assigned to them.' To a limited extent this may be admitted. Respecting private manuscript it may be true; but surely official and national records like those referred to by the Spanish secretary should be excepted. So far from rejecting such sources of information respecting the arts of former times, we should have supposed they were unexceptionable.

"But it is said, although a boiler is mentioned, that is not sufficient proof that steam was the impelling agent, since there are various machines in which fire is used under a boiler, without that fluid having anything to do with the operations. Well, but the account states that which really appears conclusive on this point, viz., that this vessel contained 'boiling water,' and that Ravago, the treasurer, opposed the scheme on the ground that there would be an exposure to danger 'in case the boiler should burst.' As this danger could not arise from the liquid contents merely, but from the accumulation of steam (the irresistible force of which was, as has been observed, well known from the employment of the eolipiles), it is obvious enough that this fluid performed an essential part in the operation—in other words, was the source of the motive power. Had it not been necessary, Garay would never have furnished in it such a plausible pretext for opposition to his project. It has also been said that if Garay used steam at all, his engine was probably the whirling eolipile. There are, however, strong objections to such an opinion. That engine, acting on the same principle of recoil as Hero's eolipile, might have been made to propel a vessel of 200 tons is admitted; but for modern experiments with small engines of this description, we know: first, that in order to produce the reported result, the elasticity of the steam employed must have been equivalent to a pressure of several atmospheres; and second, that the enormous consumption of the fluid when used in one of these engines must have required either a number of boilers or one of extraordinary dimensions. Had Garay employed several boilers, the principal difficulty would be removed, as he might then have made them sufficiently strong to resist the pressure of the confined vapor; he, however, used but one, and every person who has witnessed the operation of reacting engines will admit that a single boiler could hardly have been made to furnish the quantity of steam required at the requisite degree of tension.

"As the nature of this Spanish engine is not mentioned, every person is left to form his own opinion of it. We see no difficulty in admitting that he employed the elastic force of steam to push a piston to and fro—or that he formed a vacuum under one by condensing the vapor. Such applications of steam were as likely to occur to a person deeply engaged in devising modes of employing it, in the sixteenth as well as in the seventeenth century, notwithstanding the objection so often reiterated that the arts were not sufficiently matured for the fabrication of a metallic cylinder and piston, and apparatus for transmitting the movements of a piston to revolving mechanism. The casting and boring of pieces of ordnance show that the construction of a steam cylinder was not beyond the arts of the sixteenth century, or even of the two preceding ones; while the water works, consisting of forcing pumps worked by wheels, and also numerous other machines put in motion by cranks (and the irregularity of their movements being also regulated by fly-wheels), show that engineers at that time understood the means of converting rotary into rectilinear motions, and rectilinear into rotary ones.

"It need not excite surprise that Garay adopted paddle wheels as propellers, since they were well known before his time, being of very ancient date. Roman galleys were occasionally moved by them, and they had probably never been wholly laid aside in Europe since the fall of the empire."

* * *

Only a few years ago, for electrical resistance, electricians used German silver wire, or some other form of metal resistance. Now, where a high resistance is required, a graphite resistance rod is used. A small rod of only a fraction of an inch in diameter and a few inches long has a resistance of thousands of feet of copper wire or German silver wire.

HOW AND WHY.

A DEPARTMENT INTENDED TO CONTAIN CORRECT ANSWERS TO PRACTICAL QUESTIONS OF GENERAL INTEREST.

Give all details and name and address. The latter are for our own convenience and will not be published.

6.—Subscriber desires to build a small engine of about one-half horse-power and desires a detailed sketch and description which will enable him to go ahead without any trouble.

A.—We recommend a book which has been recently published by the D. Van Nostrand Company called "Small Engines and Boilers," written by E. P. Watson, which will give him much valuable information together with hints and best methods for making the parts.

7.—W. C. A. desires to know: 1, A method for casehardening. 2, A method for annealing cast-steel. 3, A welding compound for tool and crucible steel.

A.—The best casehardening process is quite expensive and also requires considerable time for its action. The articles are packed in an iron box with bone dust, animal charcoal or leather scraps and subjected to a high temperature for about twenty-four hours, the box being sealed so that the atmosphere is excluded.

The receptacle is then opened and the articles, while red hot, are plunged into a bath of salt water, which hardens the outside to a depth of nearly one-sixteenth of an inch. The presence of the materials mentioned, together with the high temperature, changes the iron or low carbon steel to high carbon steel to a depth that depends (within limits) on the length of the time employed. This process is extensively used by some of the best bicycle builders for hardening the cups and cones, as low carbon steel can be used and the resulting product has a harder surface than would be permissible with those made of tool steel, together with a soft center which is not as likely to fracture. A cheaper and less effective process that is much used, however, consists of the use of cyanide of potassium, which is rubbed over the piece after being heated in an ordinary forge to a high red temperature. After the article has been well coated with the cyanide, it is reheated and then plunged in cold water. The casehardening resulting by this process is very superficial and does not compare with the first process in results. More effective results may be obtained by the use of cyanide of potassium by dipping the articles into a bath of the chemical, which is kept melted, and leaving the piece for a few moments until the surface is thoroughly saturated. After being reheated, the article is dipped until cold. Precaution must be taken when using the cyanide, as the fumes are very poisonous. 2. While there are numerous schemes used for annealing tool steel, probably the best method is the simplest, which simply consists in heating the steel to a full red and then burying it in ashes or air slacked lime, so that it will cool very slowly. The heating should be done uniformly and as quickly as possible, without subjecting any part to an excessive temperature. To anneal the self-hardening steels, it is necessary to heat them in a muffle and allow them to cool without being exposed to the air. 3. There are many welding compounds on the market which give excellent results, but none of them will work miracles. The higher the percentage of carbon the greater the difficulty in welding, so the best grades of tool steel are practically unweldable. A good flux that is generally available, is clean dry sand, and it will usually give results equal to any of the so-called welding compounds.

8.—W. H. B. desires to know if the following calculation is correct for the gear of a lathe to cut the fractional thread 3¼ to the inch, the conditions being the same as those given in W. H. Van Dervoort's article in the September issue with the exception that the lead screw has six threads per inch.

$$\frac{\text{Teeth in stud gear}}{\text{Teeth in screw gear}} = \frac{1}{2} \times \frac{6}{13} = \frac{6}{26} = \frac{3 \times 2}{13 \times 2} \text{ or}$$

20 and 20 tooth gears for one pair and 30 and 130 teeth for the other pair.

A.—The expression is incorrect, since the fraction $\frac{6}{3\frac{1}{4}} = \frac{24}{13}$ instead of $\frac{6}{13}$ as given by W. H. B. We then have

$$\frac{\text{Teeth in stud gear}}{\text{Teeth in screw gear}} = \frac{1}{2} \times \frac{24}{13} = \frac{24}{26} \text{ or } \frac{2 \times 12}{2 \times 13}$$

With this proportion, 20 and 20 tooth gears as one pair and 48 and 52 as the other pair, will enable the 3¼ thread to be cut.

9.—B wants to know the composition of a metal that will melt at 240 degrees temperature. He wishes to put a fusible plug on the steam side of his boiler, and as we understand it, not over the fire but in the steam space.

A. In Kent's pocket-book the following is given for a composition that will melt at 240 degrees: Lead 1, tin 4, bismuth 5. We should advise against placing dependence in a plug of this character.

* * *

FRESH FROM THE PRESS.

SMALL ENGINES AND BOILERS, by Egbert P. Watson, a manual of instruction for the building of small engines. Over one hundred pages, with thirty full page working drawings. Published by the D. Van Nostrand Company, New York. Price, $1.25.

Many persons have at some period had a desire to build "something," and a prime mover usually proves to be the most attractive subject. For an amateur to attempt the construction of a small engine without any drawings or patterns is to invite disappointment and failure, but if the job is begun in a logical manner, there is no reason why a person with tools and a little mechanical ingenuity cannot construct an engine which will not only run but do work. The book under consideration begins with some excellent advice and gives many hints that will be found of value to the amateur, but no one should get the idea that they will be enabled by it to build an engine from old junk and without tools, for the author has set a standard of construction that only can be attained by the use of a good lathe and the necessary attachments.

While some of the designs given can scarcely be commended, we believe that they have been used in the construction of working models, and therefore the dimensions will be found reliable.

A new and handsomely illustrated magazine called "Feilden's Magazine" has appeared at London, Eng., which is intended to cover, in a comprehensive way, the various branches of industrial progress. The magazine is interesting and occupies about the same field as Cassier's Magazine in this country. Our comments with reference to it would be more favorable were it not for the fact that the publisher is evidently over sanguine of the future success of his magazine, or at least is apparently well satisfied with his present efforts, which we take to be a bad state of mind for a publisher to be in. There are several editorials containing passages like the following: "We can say with confidence that never before in the history of the trade press has such a storm of congratulatory and eulogistic comment been showered upon a new industrial publication." "It is something to be grateful for, that even in 'effete' England such a publication as this was wanted. We present the first issue with the confidence that we have produced a magazine fully up to our expectations."

ADVERTISING LITERATURE.

THE STANDARD SIZES FOR CATALOGS ARE 9 X 12, 6X9 AND 3½X6 INCHES. THE 6X9 IS RECOMMENDED, AS THIS SIZE IS MOST LIKELY TO BE PRESERVED.

The Cleveland Twist Drill Co., Cleveland, O., have sent us a complimentary copy of the Mechanics Pocket Memoranda, the excellent pocket-book issued by the International Correspondence Schools, Scranton, Pa. This book makes a very attractive and valuable advertising souvenir that will be appreciated by the many friends of the Cleveland Company who are fortunate enough to receive a copy of the book.

A large and handsomely gotten up catalogue is that issued by the U. Baird Machinery Co., Pittsburg, Pa. It contains 232 large pages printed on heavy paper, and the illustrations are much finer than those usually shown in catalogues. The line of tools includes a great variety of lathes, planers and other standard machine tools, hoists, air motors, electric motors, air compressors and many other tools and appliances.

C. H. Besly & Co., Chicago, Ill., dealers and importers of machinery, have issued a catalogue of 300 pages, which is very complete, containing as it does illustrations, descriptions and price-lists of about everything required about the shop, in the way of small tools, appliances and materials. The matter is very much condensed, with small illustrations, so that many more articles are listed than would usually be found in a catalogue of twice this number of pages. It is a handy book to have for reference.

Watson, Stillman Co., New York City, have issued a catalogue of hydraulic jacks and tools in which are shown a few of the hundreds of hydraulic tools made by them. Their system of cataloguing tools consists of issuing sheets on each of which are shown one or two tools of a similar nature. This catalogue contains about fifty of these sheets bound into pamphlet form. At the back there is an index of the other illustrated sheets, from which descriptions of any of their tools can be ordered.

We have received from the B. F. Sturtevant Co., Jamaica Plain, Boston, Mass., Bulletins H and I, describing, respectively, their momogram motors, as attached to fans and their eight-pole motors and generators.